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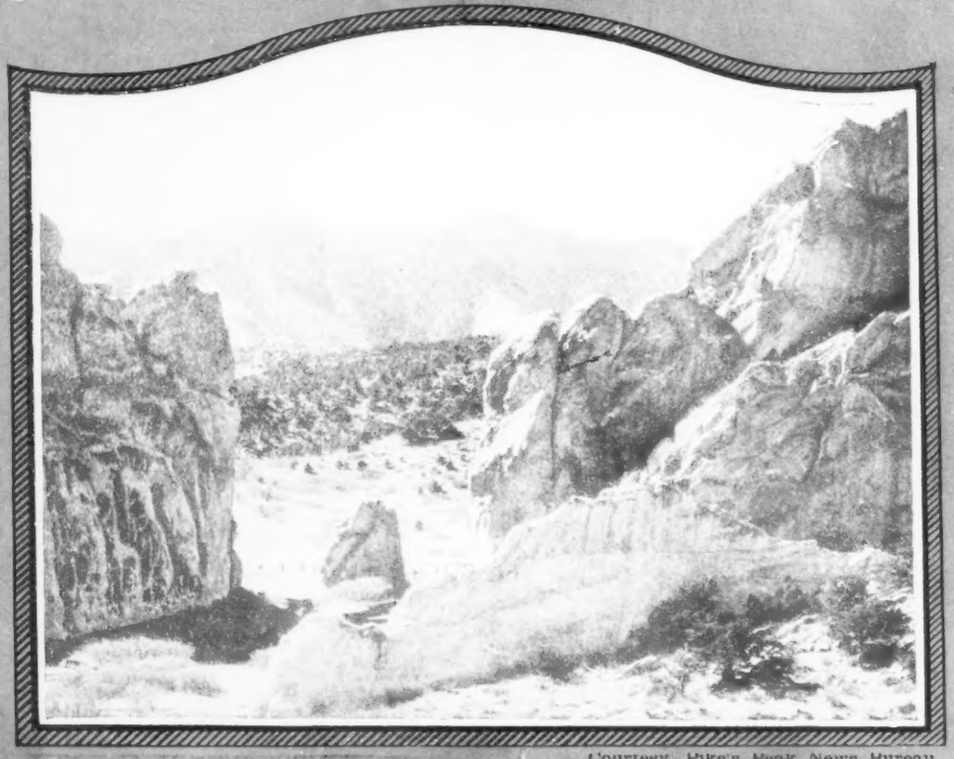

Courtesy, Pike's Peak News Bureau

IN THE GARDEN OF THE GODS WHERE NATURE HAS WROUGHT SCENIC WONDERS IN THE AGES GONE. PIKE'S PEAK IN THE DISTANCE

Story of the Portland Gold Mine
C. H. Vivian

American-Made Dolls for American Children
J. N. Whitehouse

Evolution of the Caterpillar Tractor
J. C. Knollin

Tata Hydro-Electric Project
R. H. Briggs

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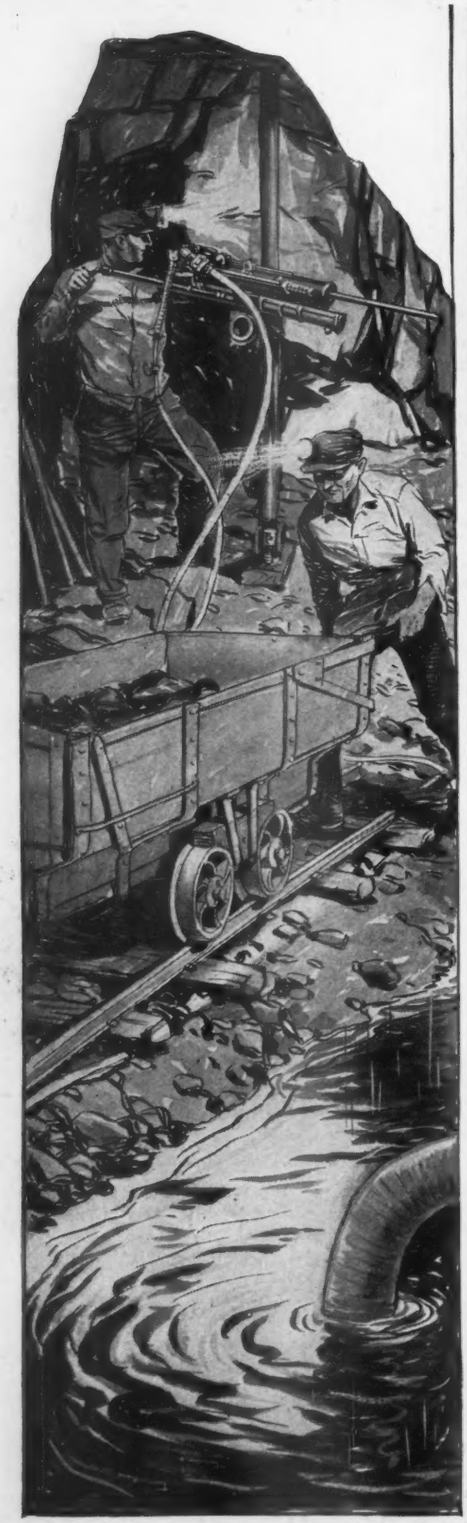

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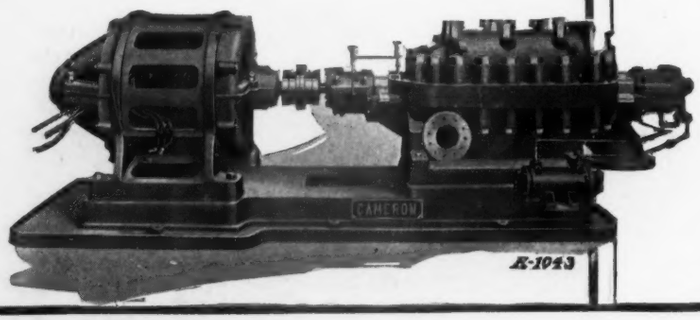

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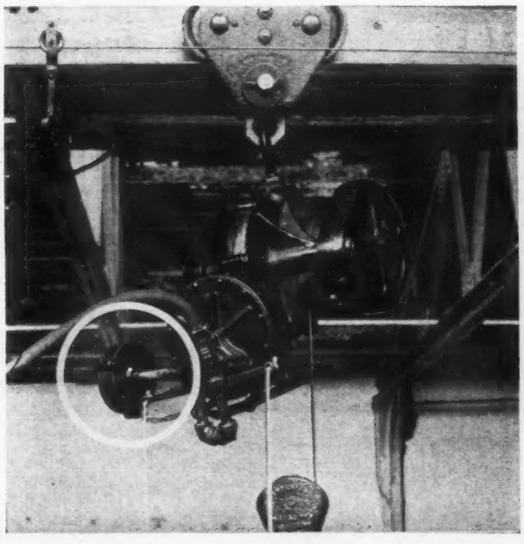

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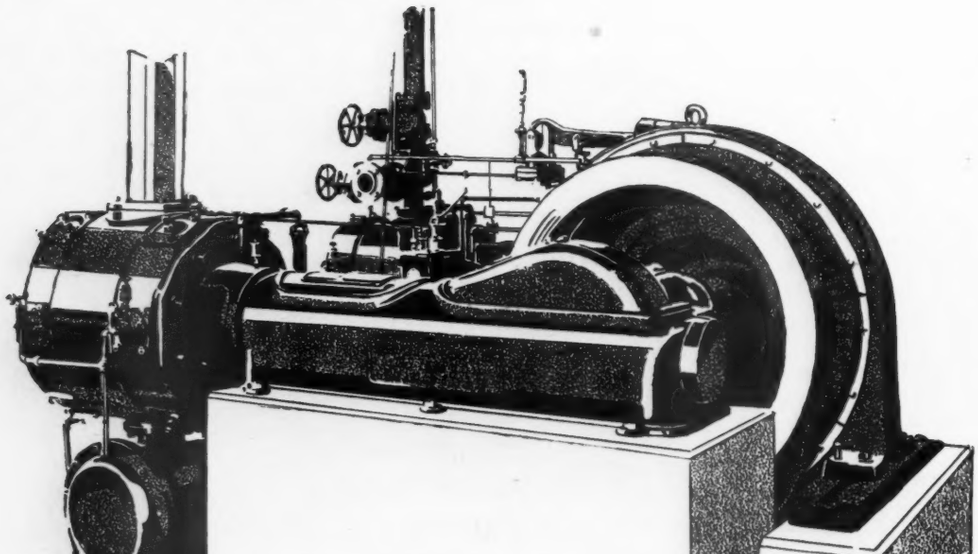

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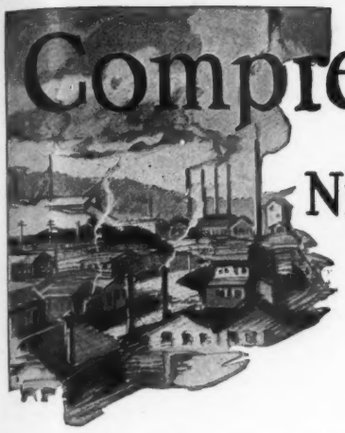

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DECEMBER, 1926

Story of the Portland Gold Mine

New Era of Production Promised in Cripple Creek Through the Success Achieved in the Working of this Property

PART I

By C. H. VIVIAN

ON a wall in the engineering offices of the Portland Gold Mining Company at Victor, Colo., is a bit of cardboard bearing these words: "The pessimist lacks practical information, intelligent application, and common courage." These words express by contrast the spirit that has dominated the Portland Gold Mining Company in its romantic career. In short, optimism, not pessimism, has been the persistent urge that has carried the company forward in winning treasure from the rock where Nature stored it in the ages gone. What the Portland has yielded has been the outcome of a stout-hearted fight against odds—the reward of hard work on the part of men that could not be dismayed.

The theory that the Portland has effectually shattered is that Cripple Creek ores play out with depth. The company is today raising $60 ore from 3,000 feet underground, twice as far as any of the other former big producers in the district carried their shafts. But figures tell the story better than words. From 1918 to 1923, inclusive, the operating deficit totaled $1,431,795. In 1920, alone, the loss was $442,094. Yet the Portland hung on. In 1924, the company's books showed a profit of $58,135; and in 1925 one of $56,660. On April 15 of this year a dividend of $60,000 was distributed—the first in six years by a company whose stock was at one time almost more to be desired than United States bank notes.

As a result of its business fearlessness, the Portland has made history in the Cripple Creek region. Not only is the company's own life assured for many years to come, but it has blazed a path for deep mining that is almost certain to result in the reopening of some of the once famous producers of the district that were abandoned when the ore shoots pinched out at the bottom.

Delving beneath the earth's crust for gold is a precarious undertaking at best; but mining for the precious metal at Cripple Creek has proved even more speculative than in most other gold fields. Fissure veins that continue unbroken for great distances through the country rock are lacking. Instead, the mineralized rock lies in a veritable network of veins that have a habit of suddenly terminating. As a result, the producing of gold at Cripple Creek has always been a more or less uncertain business. Even in the boom days, the presence of paying ore was scant assurance to any mine of continued profits. In fact, the history of the camp reveals that in unbelievably short periods entries in ledgers changed from black to red—paying mines became losing propositions.

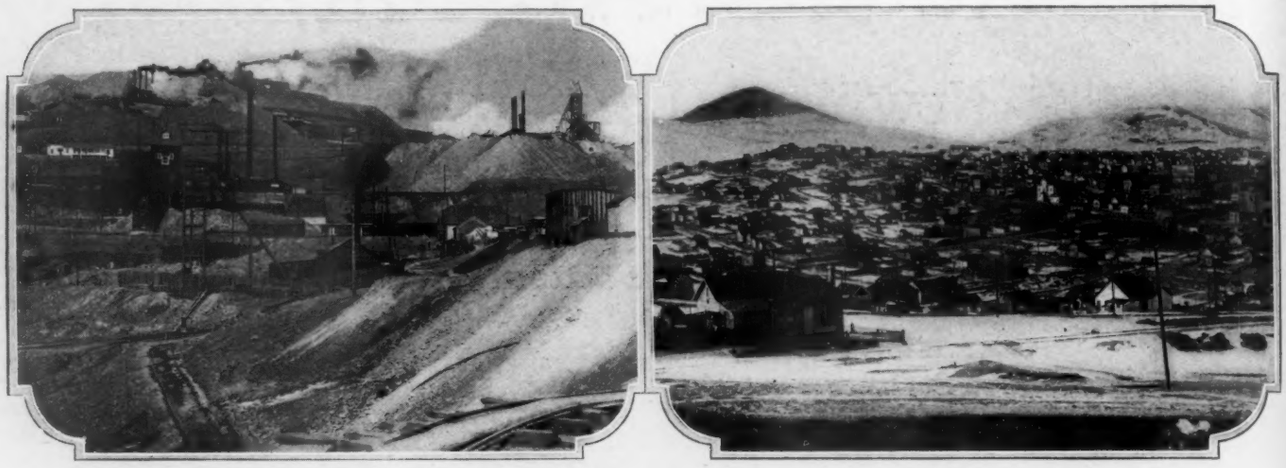
Firm in the belief that the ore horizon was shallow, most of the companies worked the gold-bearing rock that was within easy reach—abandoning the underlying ground as lean or barren. With depth, mining costs mounted. Then, too, there was water to contend with, for Cripple Creek was always a wet camp. So one by one the mines closed down, with the exception of the Portland Gold Mining Company that stands out from among the original big producers as the only one willing to take a chance when the score stood against it.

While Cripple Creek is no longer a name to conjure with it is in a fair way to "come back" because of the Portland's successful work at lower levels. And this success is no doubt mainly due to the farsighted policy adopted by the company in the development of its property. Like the squirrel that gathers winter rations in the autumn, the Portland always combined the stripping of ore bodies with exploratory work—in short, it kept its shaft several levels below the principal point of production. When it came to a choice between shutting down or taking a gamble, as was sometimes the case, there was

CRIPPLE CREEK was a name to conjure with a quarter of a century ago when that mining camp was in its prime and gold in large quantities was being garnered from the properties in that district. But as time went on, one after the other of the producers failed to yield profitably, and reluctantly the operators abandoned the mines after they had reached an average maximum depth of not more than 2,500 feet.

So far as the run of geologists could figure it out, there was no gold to be won at greater depths in the Cripple Creek district. "Why, then," they asked, "should time and money be wasted in penetrating farther into non-gold-bearing rock?" Happily, this view was not shared by the Portland Gold Mining Company.

Those men did not believe that Cripple Creek ores played out with depth; and to prove their faith in this belief they kept on working deeper into the bowels of the earth. It is a matter of record now that they were successful; and the present article makes it clear that Cripple Creek may again become wonderfully productive if a similar course is pursued with other properties in that district.



Left—Looking north from the foot of Battle Mountain with Independence Shaft in the foreground. Right—A comprehensive panorama of Cripple Creek as it appears at the present time.

never any doubt as to the course to be followed.

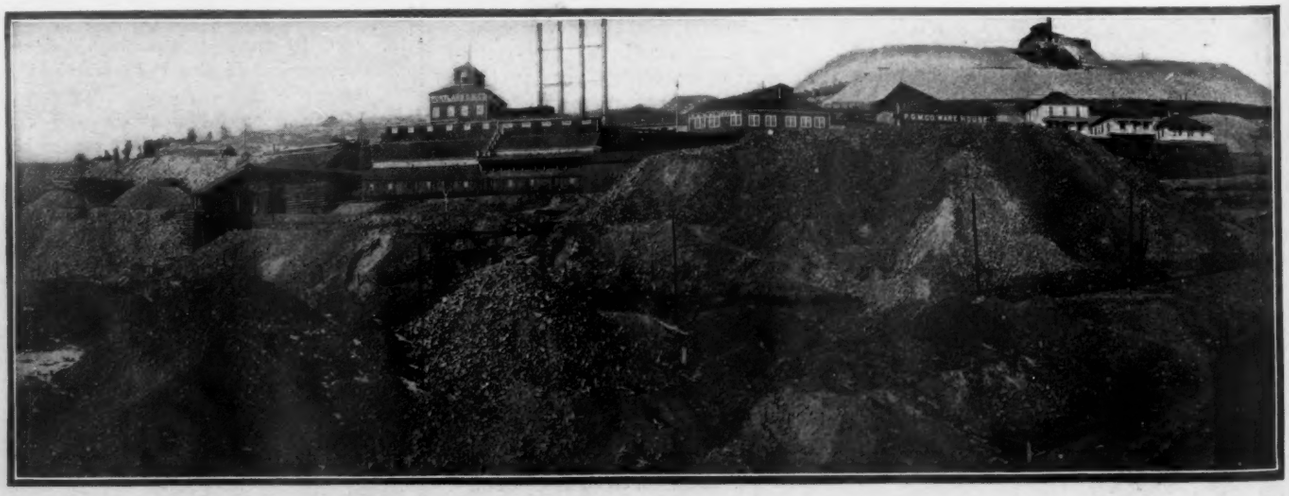
Today, the bottom of the sump of the Portland main shaft is 3,031 feet below the surface. This is some 500 feet deeper than the Cresson, which is at the present time the only other big producer in the district, and 1,500 feet lower than any of the shafts of the abandoned mines. Preparations are now underway to sink to a new station. And to give some idea of existing values, there is a partly stoped ore body at the 2,900-foot level that is estimated to contain $1,000,000 worth of recoverable gold. This vein continues through the 3,000-foot level, where a winze is being sunk to determine its depth. In addition to this known high-grade ore, so it is computed by Ray B. Emens, mine engineer, there are over 13,000,000 tons of mill dirt available. Lower levels are yet to be prospected for a continuation of several vein systems that proved very productive at higher levels.

Operations in deeper ground have brought to light several significant facts pertaining to the occurrence of the ore bodies. For example, one of the principal sources of ore was what was known as the No. 1 or contact vein. This vein had a general north and south trend and extended for several hundred feet above the 2,450-foot level. Below that level this vein was virtually barren. But, after showing only scattered values for a vertical distance of several hundred feet, it yielded screenings on the 2,700-foot level worth from $6 to $20 a ton; and now, as it is being followed still farther down, it gives every indication of resuming some of its former richness.

An even more enlightening find was made in the case of No. 1 east vein—the present principal source of ore. This rich lode did not exist above the 2,700-foot level. Moreover, its position was abnormal, inasmuch as substantially all the veins previously worked in the mine, as well as those in neighboring properties, showed a strike roughly north and south. The new lode lay east and west. Both of those developments lend credence to the present belief that the other big properties, had they continued their explorations downward, might either have encountered paying ore in their known veins or discovered surprise shoots, such as the Portland No. 1 east.

Records show that the Portland is one of the most successful gold-mining enterprises of the country. From April 1, 1894, when the present company was formed, to January 1, 1926, it produced $58,163,817 worth of the precious metal, contributing more than 15 cents to every dollar's worth of gold that Cripple Creek added to the world's supply. Out of this sum there was paid in dividends $11,692,000—a return of 380 per cent. on a capitalization of $3,000,000. In fact, in the matter of total production and dividends paid, the Portland is in the lead among Colorado mines. This record is even more impressive when it is understood that no stock was ever sold for mine development or for the purchase of equipment.

From its very inception, the Portland has proved of interest. Its discoverer, James F Doyle—who now lives in Denver, walked into the district in 1891, carrying with him all his worldly possessions. Shortly before that time Winfield Scott Stratton, a Colorado Springs carpenter and specimen collector, had located two claims in the region—signalizing the birth of Cripple Creek as a mining center. Because this happened on July 4, Stratton called one of his claims the Washington and the other the Independence. He looked upon the latter as unimportant, and gave a bond and lease on it



The original property of the Portland Gold Mining Company with Shaft No. 1 at the left and Shaft No. 2 at the right. Since this picture was taken most of the material in the dumps has been milled.

SOME STRIKING SCENES ALONG THE ROUTE TO CRIPPLE CREEK

Courtesy, Denver Tourist Bureau and Pike's Peak News Bureau.

Fig. 1—Ute Pass, on the road between Colorado Springs and Cripple Creek.

Fig. 2—Down in the canyon, on the run from Colorado Springs to Cripple Creek.

Fig. 3—Pike's Peak, named after Zebulon Montgomery Pike, who first gazed upon the mountain in 1806.

Fig. 4—Beautiful Seven Falls in South Cheyenne Canyon, Colorado Springs.

An R-51 stoper at work on the 2,900-foot level.

while he worked the Washington. Fortunately for him, however, the bond was never taken up. The Independence became world famous within a few years; and after making a profit on it of $2,400,000, Stratton sold it to the Venture Corporation of London for $10,000,000.

At the time of Stratton's discovery, the region was condemned by prospectors. Several flurries of excitement had been occasioned by the reported findings of gold float on Mount Pisgah, a few miles to the west. But these had turned out to be unfounded; and the gold seekers subsequently foreswore the entire district. When the richness of Stratton's discovery became known, however, there was a rush to the section, and the hillsides were soon plastered with locations. There were few surface outcroppings of rock—the region being one of grassy slopes on which cattle peacefully grazed, and to get to the lodes it was necessary to dig through the overlying soil and rock.

Battle Mountain was a beehive of activity when Doyle visited it. Claims seemed to dovetail and to overlap one another; and apparently not a foot of open ground was left unstaked. However, Doyle resorted to the simple expedient of running out the lines of the claims, and thus learned that a triangular piece of ground, less than an acre in area, had not been filed upon. This land was situated about 300 feet northwest of Stratton's Independence claim.

In honor of his birthplace, Portland, Me., Doyle called the claim the Portland. He set to work digging a shaft, and by his own efforts sank it 10 feet before enlisting the aid of associates. With a windlass, they excavated the opening until they struck rock at a depth of 20 feet. Not being timbered, the shaft caved in and exposed three small streaks. As Cripple Creek gold occurs with telluride, these streaks failed to show the colors associated with the precious metal found in the older mining districts of the state. Panning revealed no gold.

As Mr. Doyle puts it: "Had the pieces been roasted, they probably would have shown values. The first samples I had assayed at Colorado Springs returned a content of 139½ ounces to the ton, or a value of around $2,900 to the ton. I tried to borrow $100 on the strength of this assay to return and work the claim, but no one would believe that the ore had come from Cripple Creek. When I applied for assistance, I was asked if I had assayed a $5 goldpiece."

Associated with Doyle at the time were John Harman and James F. Burns, now dead, who was afterwards president of the Portland Gold Mining Company for a number of years. The Burns shaft, also known as the No. 1, was named for him. For some years Burns and Doyle waged a bitter controversy, which finally resulted in a victory for Burns. As a result, Doyle today has no interest in the property which he discovered.

Although the three prospectors had ore on their claim, they were unable to raise sufficient money to develop it, and were soon involved in litigation with surrounding claim owners. Their first shipment of ore was made in flour and in gunny sacks, and was hauled to Canon City by a grocer whom they owed for "grub." From Canon City it was sent to the Pueblo smelter. It showed a value of 36 ounces of gold to the ton. "This gave us courage and some money," states Doyle. "We put a little board shack up over the collar of the shaft, and I made my blanket bed there."

After a group of Boston men had tried unsuccessfully to operate the property, Stratton came to the aid of Doyle, Burns, and Harman. They acquired an additional claim, and organi ed a $3,000,000 company with Stratton as its first president. From February 4, 1894,

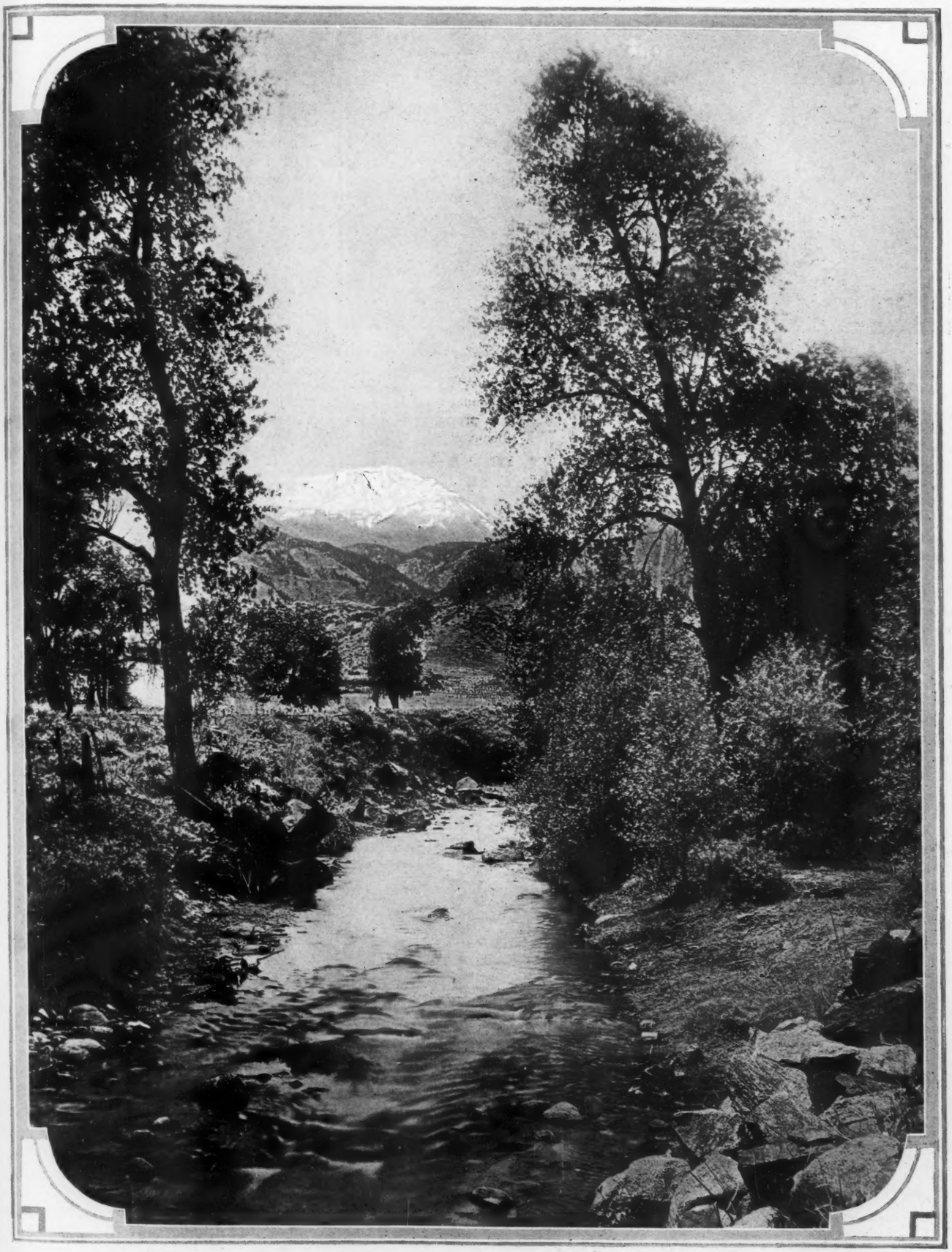
"Jackhamer" drilling in a winze in one of the Portland mines.

the date of incorporation, until April 1 of that year, the company operated at a deficit of $5,000. At that time the active management was transferred to Mr. Burns as general manager and treasurer. He assumed charge without a dollar in the treasury.

When the company was formed the property consisted of the Portland and the Bobtail No. 2 claims, covering less than two acres of surface ground. However, they included the apexes of several veins, and gave the company a wedge which enabled it to enforce its rights against the Battle Mountain Mining Company and other claimants. In all, 47 suits were filed against the Portland that first year. By purchasing five key claims for $265,000, a compromise was effected. Portland holdings thus grew to 19 claims of 100 acres. Of these, 12 claims were owned outright and 7 others were controlled. There were 7 shafts, of which the Portland, of 426 feet, was the deepest.

General view of the property of the Portland Gold Mining Company as it appeared in 1896.

At the close of the first year 7,826 tons of ore, with a gross value of $553,975, had been produced. After paying the first dividend, amounting to $67,290, there remained a cash balance of $131,542. Of the 3,000,000 authorized shares, 757,000 had not been issued. In tendering his first annual report on February 4, 1895, Manager Burns wrote: "By an analysis of the tonnage produced and value received, the property ranks second to none in the district. With the values being main-



Courtesy, Denver Tourist Bureau.

Pike's Peak glimmering in the summer sunshine. A bit of beautiful scenery on the road to Cripple Creek.

One of the Portland properties, the Modoc Mine, at Victor, Colo.

tained and ore bodies increasing in size as depth is obtained, with the large area of virgin territory yet to be explored, the dividend-earning power of the property is practically assured." The following years proved this prediction to be, indeed, conservative.

In 1895 an apex suit against the company was settled by purchasing 14 claims, for $373,000, and 752,000 shares of stock. This brought the holdings up to 135 acres. In the second year of its operations, the Portland produced 31,516 tons of ore having a gross value of $1,700,094. The net profit on this output amounted to $1,014,745; and dividends to the sum of $479,710 were paid.

By 1897 all the workings had been connected with the Burns shaft, and in the following year that shaft was used exclusively. In 1898 the company acquired the Rex holdings, to the east, of 10 acres, and the Morse group of 38 acres lying to the north—making in all 183 acres. During the next few years the Portland continued to increase in value; and it soon began to show signs of exceeding even the renowned Independence in richness. In 1901 the fame of the property was such that President Roosevelt visited it, while on his western trip, and went underground as far as the 600-foot level, where he viewed the process of taking the ore from the stopes.

(To be continued)

CUTTING DOWN WASTE IN SLATE INDUSTRY

IN recent years, the United States Bureau of Mines has given considerable attention to the slate industry, thereby undoubtedly contributing to its promotion and expansion. Because of the work done by this Government bureau, the quarrying and the preparing of slate for the market have been rendered far less wasteful both of labor and material, resulting in a product of wider adaptability. Roofing slate, formerly produced almost entirely by hand, is now turned out by mills equipped with traveling cranes, power saws, and special pneumatic splitters.

Architecturally, besides its increasing use for roofing, slate is utilized to surface walls and to make stair treads, floor tile, and base boards, and it is also employed in the manufacture of electrical switchboards, blackboards, billiard tables, etc. Valuable information on the subject has recently been published by the Bureau of Mines in their Bulletin 218, entitled *"The Technology of Slate."*

Office of the Portland Gold Mining Company with Shaft No. 2 in the background. This shaft goes to a depth of 3,031 feet.

INCREASING THE FLUIDITY OF CONCRETE

ALONG the line of the Southern Pacific Railroad there are many miles of tunnels. These passageways are lined with timbers faced with concrete. In the past, the work of keeping the walls of the tunnels in good condition proved somewhat of a problem both as regards labor and cost. Of late years, however, their maintenance has been greatly simplified by the pneumatic placing of concrete which makes it possible to mix the material at a central base and, by the use of compressed air, to force the mixture through piping to the point of operation.

In the beginning, the men on the job experienced one difficulty—the bends in the conveying pipe wore out quickly. It was found that the bends had to be replaced with a fair measure of frequency because of the pounding and the friction to which they were subjected by the rapidly moving mass. We are told in *Railway Engineering & Maintenance* that this difficulty was largely overcome "by putting in the concrete mix a substance known as Celite." By adding five pounds of this ingredient to every bag of cement used, the friction was so reduced that the life of the bends was measurably increased.

Celite, or diatomaceous silica, has a tendency, so it is said, to increase both the workability and the plasticity of the mix; and to these characteristics is attributed the reduction in the friction of the moving mass.

WHAT IT MEANS TO RUN A TRAIN

SOME interesting and at the same time startling figures have been compiled latterly by George D. Kohler, an engineer on the Reading Railroad, in connection with the efforts exerted by the man at the throttle and the fireman in making a run from Philadelphia to Pottsville and return. On that 200-mile trip they perform 5,123 individual acts, which are divided up as follows: steam throttle is operated 928 times; whistle, 268; brake valve, 90; blower valve, 1,100; air fire door, 945; bell ringer, 200; sand leech, 80; right injector, 700; left injector, 30; water-gage tests, 30; and equalizing brake and discharge valve, 752.

In addition to all these activities, there is the road to watch with all its signals, semaphores, curves, water stations, junctions, highway crossings, passenger stations, bridges, culverts, and tunnels. Taking all this physical and mental work into consideration, Mr. Kohler has estimated that 38 foot-tons of effort are exerted in making the round trip in question.

A total of 300,000 motor cars in the United States and Canada used distilled glycerine instead of alcohol last winter as an anti-freeze mixture. Distilled glycerine will not evaporate, and one filling of the cooling system will last throughout the driving season, provided the solution is not lost through leakage.

Grouting Done With Air Seals Leaky Dam

Novel Arrangement of Air Control Made it Possible to Apply the Material Without Injury to the Weakened Structure

BY A. M. HOFFMANN

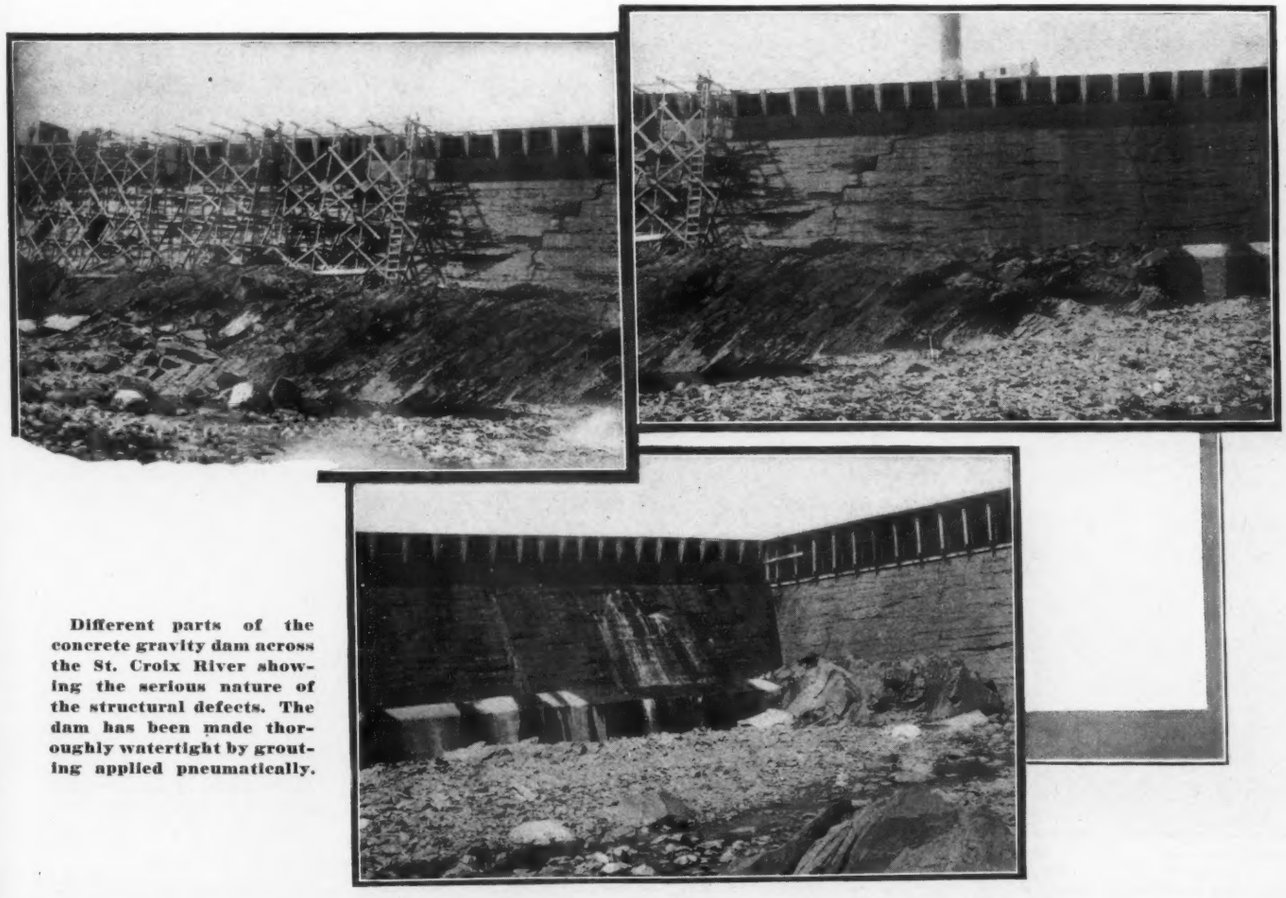
THERE is no doubt about it that the man who is called upon to do repair work is sometimes up against it. How is the work to be done? What is the best line of procedure? Such are the problems that not infrequently confront him and must be solved if lasting results are to be obtained. Just how much resourcefulness he is on occasions called upon to show was strikingly emphasized in the case of a concrete gravity dam, across the St. Croix River, in Maine, a section of which was badly in need of repair because of considerable leakage.

The dam in question, which was built in extremely cold weather, proved somewhat defective right from the start—the volume of leakage or seepage ranging all the way from a trickle to jets of water that spurted out for some distance from the downstream face of the structure. The upstream side was found by divers to be sound. The action of the frost in subsequent years so aggravated conditions that water, flowing down the injured face of the dam, tore away large pieces of the disintegrated concrete. Just what the situation was when the work of repair was undertaken is plainly shown by some of the accompanying photographs.

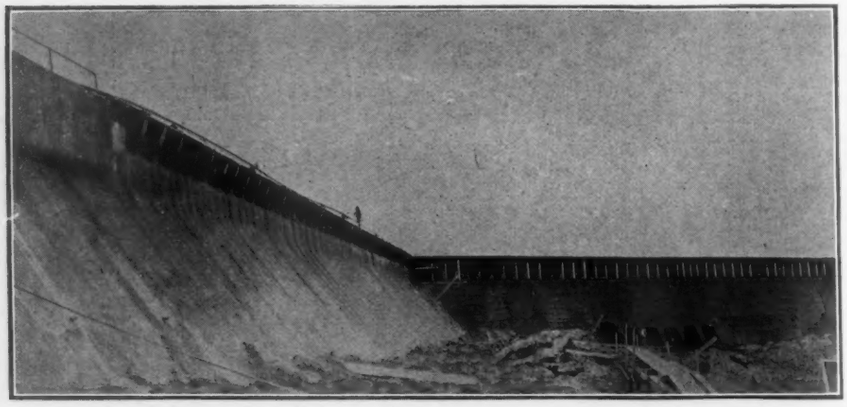
When the matter was taken under advisement, it was at first planned to plug up all the holes and openings and then to cover the entire surface with a coating of concrete applied pneumatically. But upon second consideration it was perfectly obvious that lasting results could not be obtained in this way. As the damaged section of the dam was thoroughly water soaked, it was realized that it would be only a matter of time before the erosive action of the frost would again cause the surface to crack and to spall. There was only one thing to do to prevent leakage, and that was to make the dam a solid and a homogeneous mass through which water could not penetrate. But how was the work to be done so that it would not be prohibitively costly? To bare the whole dam either by unwatering the lake or constructing a cofferdam on the upstream side could not be thought of because of the expense involved. It was therefore decided to resort to grouting—that is, to fill the damaged sections with concrete applied under pressure.

However, before this work could be undertaken it was necessary to clean all the surfaces and holes that were to be covered and filled with concrete. There was a thick coating of slime on the downstream face of the dam, and it was known that this material had also penetrated the structure by way of numerous cracks and crevices. Obviously, it had to be removed if a perfect bond between the old concrete and the grout was to be assured. By forcing a weak solution of potassium permanganate into the dam under high pressure it was possible to get rid of the objectionable matter—the slime oxidizing instantly upon contact with the solution, thus leaving the surface clean.

The dam was built in the shape of an L—the two wings having a length of 300 feet and of 1,200 feet, respectively. The 300-foot length being in the worst condition, it was the



Different parts of the concrete gravity dam across the St. Croix River showing the serious nature of the structural defects. The dam has been made thoroughly watertight by grouting applied pneumatically.



Near view of the downstream face of the dam after the grouting had been applied to the leaky structure.

first to be cleaned and subjected to grouting. The contract for the job was awarded to the Cement-Gun Construction Company, of Chicago, Ill.

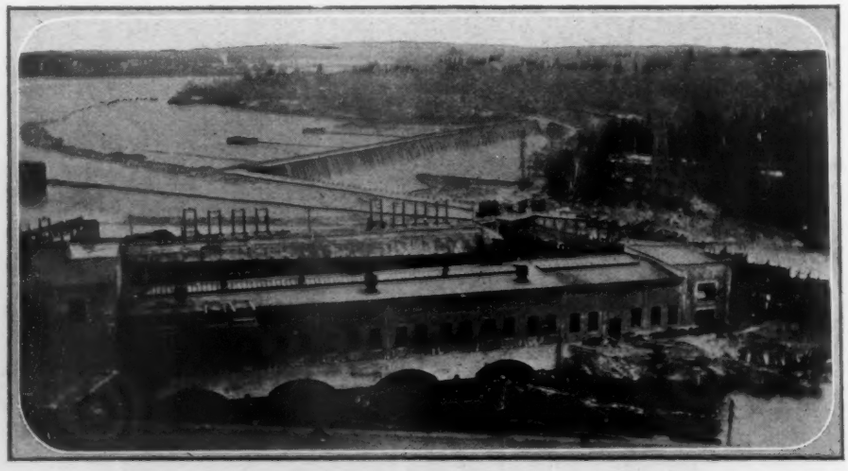
The necessary air was furnished by large compressors in the St. Croix Paper Company's mill, and piped to the scene of activities at a pressure of about 100 pounds. Reducing valves were used to bring the air down to the desired working pressure. Holes were drilled in the dam, some of them from the top and some of them from the downstream face, as the judgment of the superintendent in charge of the work dictated. Into these was secured 2-inch piping through which to force the cement grout.

The question raised at this point was: Under how much pressure was the grouting to be applied? Obviously, care had to be exercised, for had air at a pressure of 100 pounds been turned on some of the holes near the top it would probably have been sufficient to lift off the crest of the dam. To prevent any such catastrophe, a tank, about 3 feet in diameter and 4 feet high, was placed between the grouting machine and the air line. This tank was provided with a gage so that it could be filled with air at the desired pressure. When filled, the tank was shut off from the main air line and connected with the grouting machine. It was thus possible at all times to control the air pressure on the grouting machine—in short, to apply the grout with air at a pressure of 10 pounds and up.

This arrangement served another useful purpose. If the gage remained stationary, after the air from the tank was being fed to the grouting machine, it was known that one of two things had happened: either the grouting was completed or there was a choke in the line. On the other hand, if the gage went down, it was an indication that the grouting was going along all right.

Cement grout, with various admixtures of accelerating or retarding compounds, was forced into the structure until the downstream face of the dam was thoroughly sealed.

With the grouting completed, the next step in the operation was to finish off the outer surface with a coating of "Guncrete," consisting of 1 part Portland cement and 3½ parts sand. To this end, steel reinforcing rods and wire mesh were secured to the downstream face by means of anchor bolts; and then the "Guncrete" was shot in place under pressure until the entire wall presented an unbroken face.



General view of the St. Croix Paper Company's plant at Woodland, Me.

PUTTING DOWN THE WORLD'S DEEPEST DRILL HOLE

IF mechanically possible, the Chanslor-Canfield Midway Oil Company is going to put its Olinda No. 96 down to a depth of 10,000 feet. At the present writing, the well is 8,046 feet deep—already by far the deepest hole ever drilled by man. According to the *Los Angeles Times:*

"Olinda No. 96 is now standing with 4½-inch casing set on the bottom of the hole. The management announced originally that it planned to plug the hole back by stages, testing everything as far up as 3,400 feet, where the well is expected to be placed on production.

"In the meantime it has become known that a string of specially constructed 2-inch drill pipe has been ordered to go back in the hole and drill it till 'she busts.' Drilling officials hope to put the well down to 10,000 feet; but as so terrific a strain has never before been placed on drilling equipment that depth may never be reached.

"Nevertheless, with the hole in perfect condition, and casing all the way to the bottom, the company is conceded to have a fair chance to be the first to penetrate two miles into the earth. The principal thing that is likely to prevent this is the possibility of a twist-off, which at such extreme depths would present a fishing job of unprecedented difficulty. The torsion which is applied to a drill tends to twist off the bit and the lower joints of drill-pipe, and this tendency increases in proportion to the length of the drill-stem.

"As to the possibility of production at such extreme depths, geologists do not give the company much hope. The deepening project appears to be somewhat of a sporting proposition, although the experiment undoubtedly will have great value by adding to the present knowledge of deep formations, as well as to the present knowledge of deep-well drilling technique.

"What may be found at greater depths in this hole is a matter of conjecture. The drill is reported to have passed through 12 different strata of water on the way down to 8,000 feet; and at the bottom, where there is now a cement plug, the temperature is 233° F. The heat is said to be increasing at a rate of about 1 degree to each 50 feet."

UNUSUAL FIND OF BORAX IN CALIFORNIA

TO hunt for a borax deposit beneath the featureless surface of sand and gravel of a broad alluvial plain—such as is common in the deserts of southern California, might seem to the average reader like looking for the proverbial needle in a haystack. Nevertheless, back in 1913, in drilling a well in ground of this sort on the ranch of Dr. John K. Suckow, in Kern County, colemanite—the principal ore of borax—was struck after penetrating bedrock underlying the alluvial cover. Considerable exploratory work followed this discovery; and the district is believed to be of considerable promise.

Evolution of the Caterpillar Tractor

In the Manufacture and the Assembling of These Widely Used Machines Compressed Air is Employed Extensively

By J. C. KNOLLIN

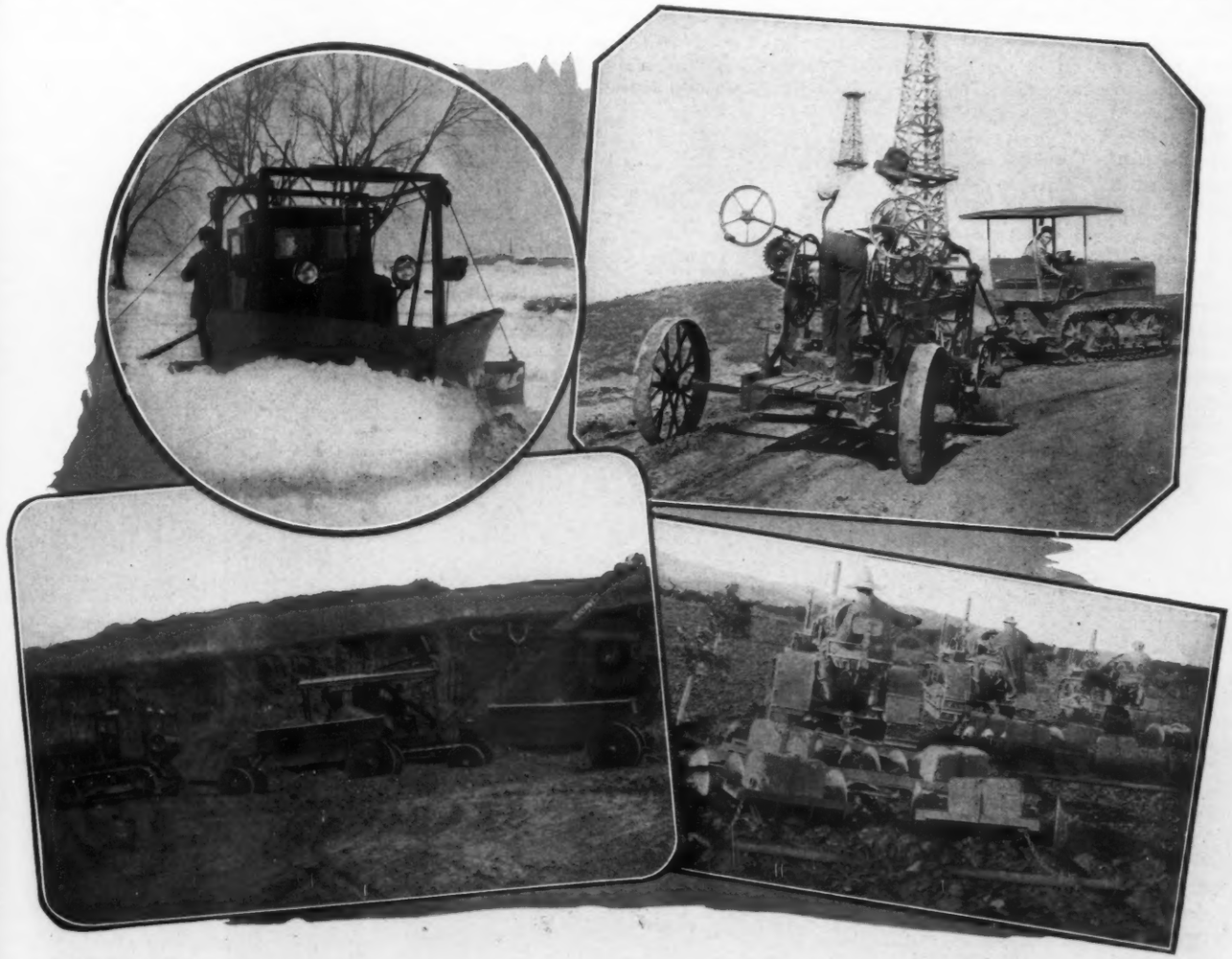
IT WAS not until the development, by the British Army, of the death-dealing "tank" that the track-laying tractor really came into its own. And, strangely enough, it was a machine originally designed for the most peaceful pastoral pursuits that was thus converted for the cruel purposes of Mars.

But this incident served to focus the attention of the world upon the traction principle that is the outstanding feature of the caterpillar tractor; and, ever since, the track-laying tractor has found an ever-widening field of usefulness. "Caterpillars" now serve industry and agriculture in endless ways throughout the civilized world. Originally, however, the vision of the inventors did not extend beyond the most elementary and local agricultural applications. Necessity, mother of so many great inventions, supplied the incentive for the first track-layer; and, by reason of conditions peculiar to the Pacific coast, where farming is pursued on an extensive scale, the principal development of high-power traction engines, both steam and gasoline, was centered in California.

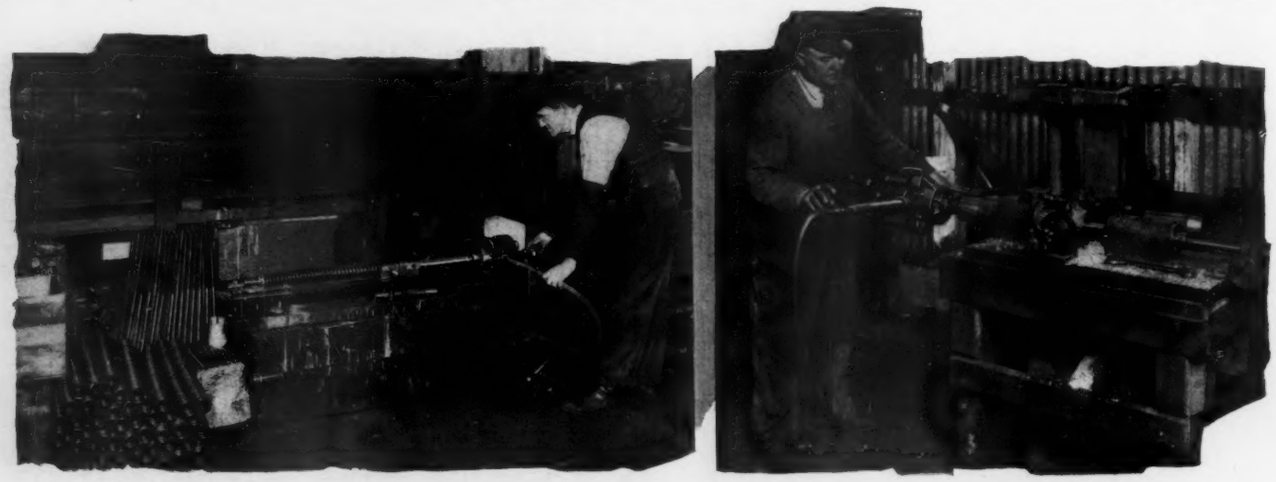
During the latter part of the nineteenth century, the demand on the part of the large landholders for some sort of power more efficient than the horse became so general that many inventors and manufacturers attacked the problem. Two men of the West stand out as the pioneers in this line of effort who evolved successful solutions—namely, Benjamin Holt, of Stockton, and Daniel Best, of San Leandro, Calif. Both organized companies for the manufacture of heavy-duty steam tractors, which soon demonstrated their adaptability.

But those tractors had their limitations. While they performed satisfactorily during the summer months, they were virtually useless during the rainy season. Because of their great weight, they would sink into the soft ground; and, unless good traction could be obtained, were practically helpless. Then, too, the necessity of supplying fuel in the form of wood or coal proved a handicap.

The inventors continued their efforts, recognizing the need of a machine that would work under all circumstances, regardless of the state of the soils, the condition of the roads, or the steepness of the grades. At the same time, Eastern manufacturers brought out smaller steam-traction engines which were



Top, left—What happens to the snow when a caterpillar gets behind the plow. Right—A 5-ton caterpillar engaged in road making in a California oil field.
Bottom, left—The caterpillar makes light work of hauling five tons of earth at a time. Right—Caterpillars cultivating the ground in a large California orchard.



Left—Air-operated drills are used to assemble the recoil springs for track idlers. Right—Reaming the bearings of a connecting rod with an air-driven drill.

used largely to haul and to operate threshing machines.

But the California manufacturers were now working along different lines. About 1898 there was built for Charles Moreing, owner of soft-peat sediment lands in the San Joaquin River delta, a tractor which had wheels 8 feet in diameter and 18 feet wide. The difficulty with this enormous engine was that its weight increased in proportion to the width of its wheels—little advantage thus being gained thereby.

All this groping in the dark bore fruit, however, for about this time Benjamin Holt realized that an entirely different principle must be worked out if a tractor was to be produced that would perform successfully under all conditions. He built a pair of tracks or "platform wheels," as he then called them, and tried them on one of the old steam tractors. The material for this first crawler tread came from the scrap pile about Mr. Holt's shop, but the result was so satisfactory that he was encouraged to continue his experiments. The next attempt was still more successful; and thus the modern caterpillar tread came into being.

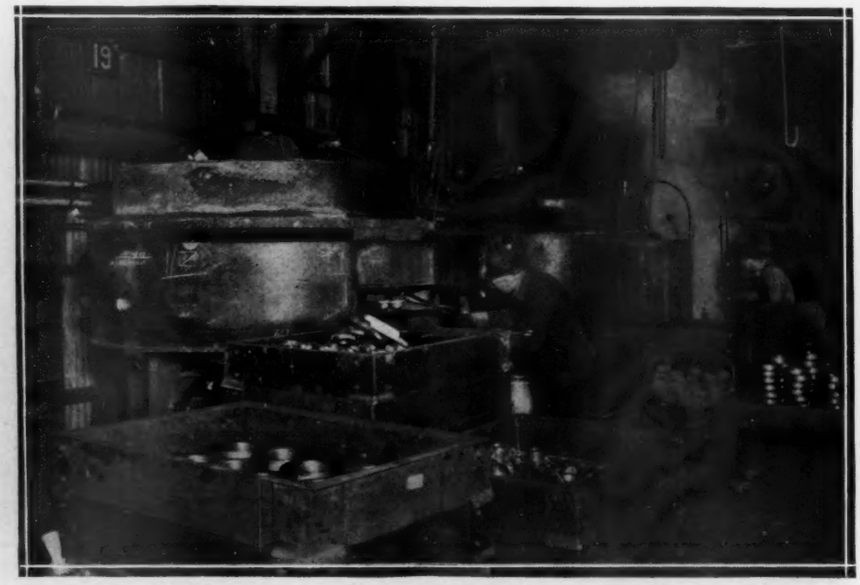
Nobody in those days realized how far reaching would be the effect of this development. Even Benjamin Holt and his associates believed that the new track-layer would be employed only under special conditions. Not until 1905 were gasoline-propelled, track-laying tractors put to commercial use. After two years of developmental work on the soft, sediment lands of the delta, they performed their first heavy, industrial service in the construction of the Los Angeles aqueduct across the Mojave Desert. Thus did the caterpillar enter upon a larger and a constantly growing field of usefulness.

Strangely enough, the destructive purposes of war brought out the constructive value of the tractor as nothing else could have done and hastened its improvement by years. For it was at that time that more attention began to be paid to methods of manufacture, materials, simplified design, and other factors which increased the efficiency and lengthened the life of the machine.

How the caterpillar was used by the various governments for military purposes is now a matter of common knowledge. During that hostile period, the influence of army engineers made itself felt in many refinements and in important simplifications in design. As a result of further study, the modern caterpillar has over 4,000 fewer parts than the one manufactured before the war! An officer of the Ordnance Department of the United States Army is now regularly stationed at the California factory and serves as a point of contact between the makers and the War Department.

The necessity for advanced engineering practices in tractor manufacture may be easily understood when the conditions are considered under which these machines must work. The tractor is subjected to far greater abuse than the average motor vehicle. It is forced to carry substantially its maximum load at all times. It must operate under the most adverse conditions, frequently in dust, dirt, sand, and mud; and, finally, it must run for long periods, ofttimes day and night, without a stop. But modern engineering methods, especially the protection of all moving parts, has overcome these difficulties.

The modern tractor, if it is to be successful, must be designed on scientific lines; must be built from the best materials obtainable—some of them carefully heat treated; and rigid precision standards of manufacture must be adhered to. Naturally, the consistent effort towards refinement in design and improvement in manufacturing methods has resulted in the adoption of compressed-air equipment throughout the caterpillar factories.



A corner of the very important heat-treating department.

Years ago, The Holt Manufacturing Company, at Peoria, and the C. L. Best Tractor Company, at San Leandro—the two great firms whose merger in the spring of 1925 formed the Caterpillar Tractor Company, established compressed-air units in their respective plants. It is interesting to note the part that compressed air plays in nearly every step in caterpillar manufacturing processes, which are acknowledged to be among the most efficient examples of construction and assembly in the automotive world.

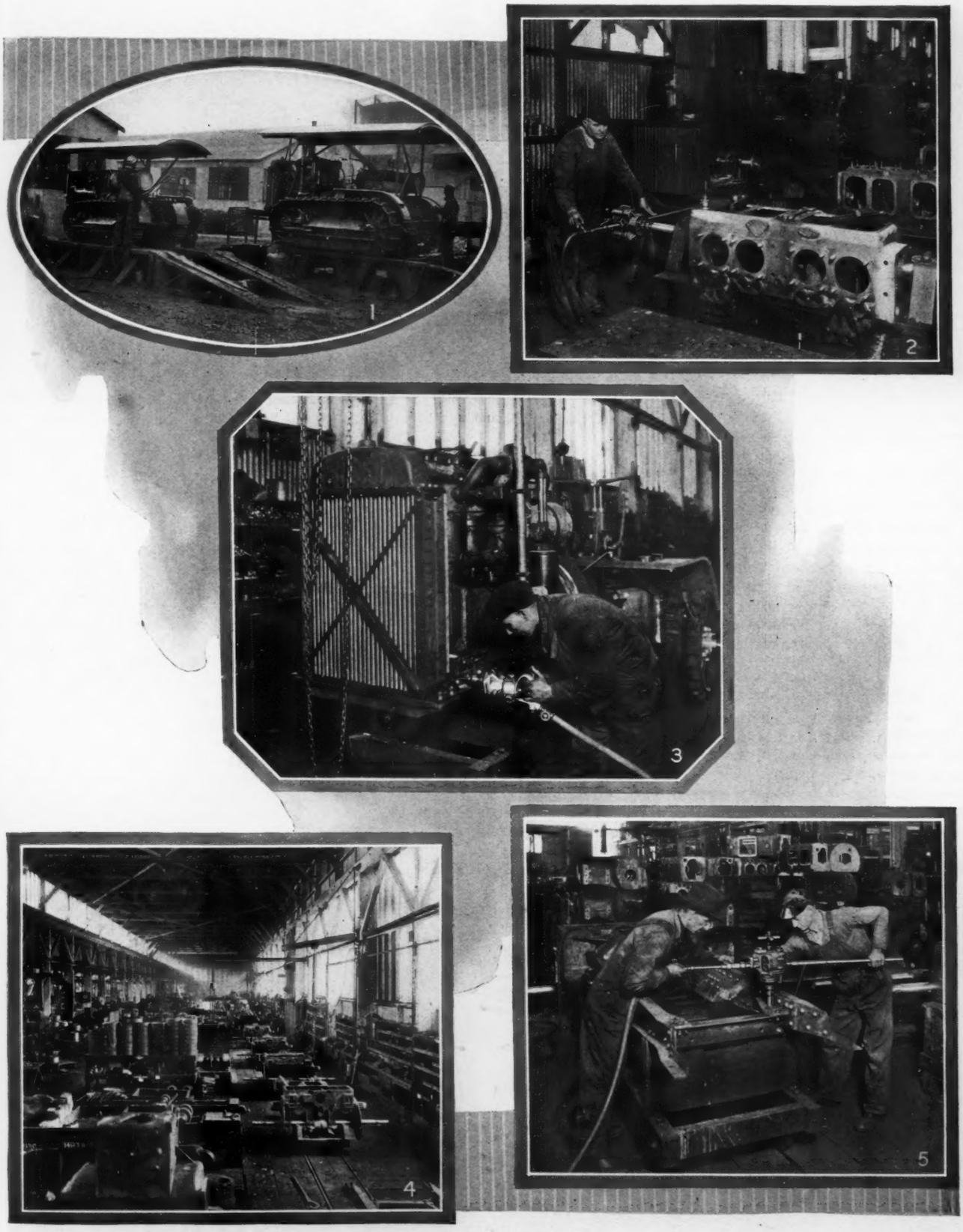
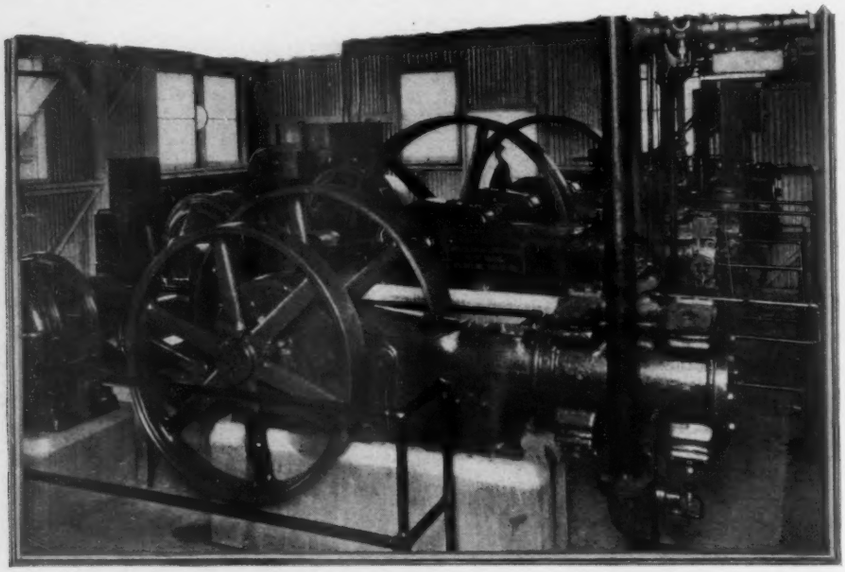


Fig. 1—Compressed air does its bit in cleaning and painting tractors after they have run their final shop tests.
Fig. 2—Pneumatic drill line-reaming main bearings of a tractor.
Fig. 3—Small I-R drill making ⅛-inch holes for a name plate.
Fig. 4—The assembly line of a group of caterpillar tractors.
Fig. 5—Air-driven drill pulling up tight ¾-inch bolts on the frame of a caterpillar tractor.



These three compressors provide the needful operating air in the San Leandro plant of the Caterpillar Tractor Company.

Drilling, as an example, is almost in its entirety a compressed-air operation. It is, doubtless, one of the most important steps in tractor manufacture, inasmuch as accuracy to minute fractions of an inch is an obvious necessity. Drilling precedes riveting, which, by the way, is also done by means of compressed air. Air-driven drills put holes in name plates; drills are employed in the assembly of recoil springs for track idlers—intricate mechanisms peculiar to caterpillars; there are drills to tighten frame bolts; and drills for the purpose of reaming bearings wherever bearings are used, which includes many vital spots.

Again, compressed air does its work in the operating of hoists—in lifting and shifting parts for further assembly with an accuracy and a rapidity that makes for great production speed. Riveting, already mentioned, is done entirely by compressed air. The tremendous force and the regular beat of the riveting hammers are made possible by a continuous flow of air power that never varies in its strength and thus makes tight rivets a certainty. Grinding, too, is done with air-operated machinery; and the accuracy of this work, sometimes most delicate, is made the more positive by reason of the varying pressure of the force behind the tool.

Nor is the work which compressed air does for the Caterpillar Tractor Company limited wholly to tractor production. This flexible medium is used around the plant in countless ways, such as in chipping, concrete breaking, etc. In turning out tractors it plays its final part when paint is applied, in an atomized form, by compressed-air sprays which throw minute particles of paint into every recess in a few moments—work which could not be done by hand in hours of time.

The Caterpillar Tractor Company has but recently installed at its San Leandro plant a new compressed-air unit in addition to those already in operation. This unit, a 2-stage compressor, with 5-step clearance-control regulator, is a duplicate of one put in service less than a year before. It furnishes air at 100 pounds pressure; and is adjustable to full, three-quarter, half, and quarter loads.

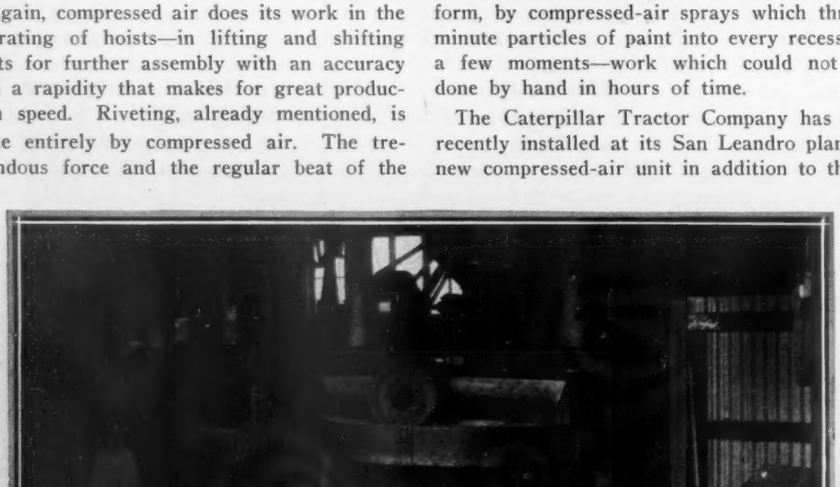
Technically, it is known as a 15&9¼x12-inch Type "B2." Two others, a 14&9x12-inch "B2" machine, operating "all on" or "all off," and a 12x10-inch straight-line, single-cylinder "ER-1" compressor, are doing their parts in enabling the company to handle the biggest production in its history, or in the history of the combined business of the two concerns which form it.

It was through a realization of the fact that the caterpillar tractor could be adapted to almost any condition, no matter how difficult, that its increasing value to industry was recognized. Now, the industrial uses of this tractor seem almost unlimited: new applications for it are being discovered almost daily by manufacturers, engineers, and contractors.

Roadbuilding, of course, is its most important field, and includes not only grading but also clearing land, removing trees and stumps, making cuts and fills, filling in around culverts and bridgeheads, constructing subgrades for paved roads, building and cleaning ditches, and hauling materials. Municipalities use track layers for park construction and maintenance, for hauling refuse, for garbage disposal, and for many other purposes. Both cities and counties, as well as bus-transportation companies, street railways, industrial plants, and others, employ these machines for snow removal.

Another broad field of usefulness is in the woods. In the Sierras of California, and in Oregon and Washington, they are utilized to transport 20-ton loads of logs which are fastened under the arch of mammoth 2-wheeled steel carriers equipped with hydraulic-lifts actuated by power from the tractor motors. In other districts, the front ends of enormous logs are carried upon low-wheeled or track-laying "bummers" or "dollies." Elsewhere, logs are skidded on the ground, transported on sleighs, or dragged through swamp lands on wide-tired trailer wagons hauled by tractors. In northern logging regions, sled trains, carrying 200 tons or more, are drawn in this fashion. In the Southern lumber belt, the hauling is done largely on 8-wheeled trailers.

The caterpillar tractor now has so many uses in industry that it would be almost impossible to describe them all. These adaptable machines haul lumber, pulpwood, and cordwood; work in clay, gravel, and sand pits; and perform many services in mines and quarries, in brick yards, and in tile works. Tractors are assisting in oil-well development and taking part in the exploration of both domestic and foreign fields, while in oil fields already opened up they are helping to build roads and are hauling pipe-line materials and machinery. They are working on levee and revetment jobs, canal construction, dam and reservoir undertakings, reclamation projects, and on townsite and subdivision developments.



Gears and other parts are sand blasted after heat treating.

Left—A Size Sixty caterpillar pulling logs over the snow in a Michigan woods.
Right—The caterpillar tractor doing effective work in hauling big sections of sewer pipe.

Railroads employ these tractors for construction work, and power companies for clearing the pole line right-of-way and for hauling poles and cable reels. Track-layers have found a wide field of application in the building and the maintenance of stadiums, baseball parks, race tracks, amusement parks, golf courses, and cemeteries. They are used for moving houses and for transporting heavy machinery of various kinds. Municipalities and public-utility companies keep them for sewer-, gas-, and water-main work. With a "bulldoze" or backfiller, mounted in front of the tractor, backfilling of trenches is quickly and easily accomplished at a remarkable saving in cost.

Caterpillars perform many helpful services in and around steel plants, glass and pottery works, paper and lumber mills, cement and chemical works, foundries, and sugar refineries.

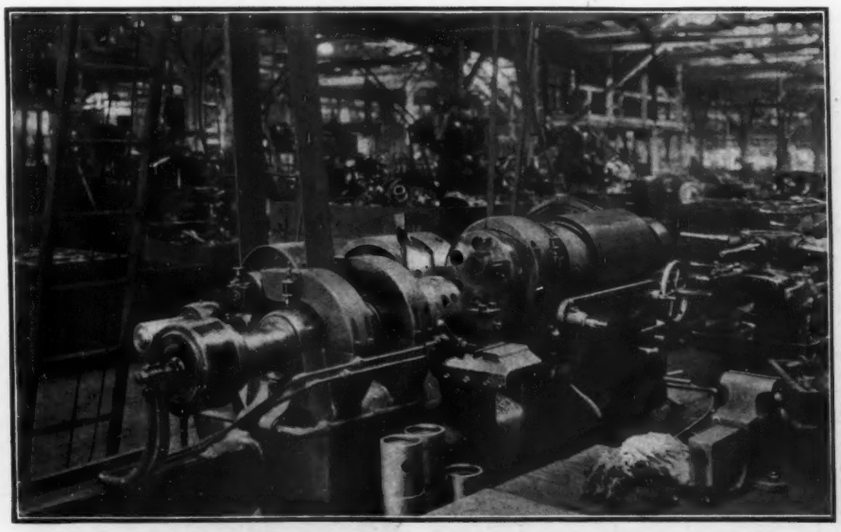
They have been used in constructing ponds on a goldfish farm, as well as for purposes of cultivation on a bulb farm; and, as an example of emergency, they have even been instrumental in dragging unfortunate cows and horses from mud holes or streams in which they had become mired. In fact, there seems to be no end to the usefulness of this powerful engine, which lays its own tracks. It is distinctly a product of American genius and business ability, and is now known in nearly every country of the world.

Almost within one generation, the business of manufacturing caterpillar tractors has developed from a local institution, centered in an inventor's machine shop, to two great factories with world-wide distribution and an annual output valued at more than $20,000,000. And in this amazing story of development compressed air has had an ever increasing share.

TELEPHONE SERVICE ABOARD A MODERN LINER

THE building of ships for passenger service is a far more complicated business today than it used to be, as modern conveniences are as much in demand on shipboard as they are on land in a hotel, let us say. Take the new liner *Malolo*, for example, the swiftest passenger vessel ever constructed in the United States and operated by the Matson Navigation Company between San Francisco and Honolulu. The telephone equipment required for that craft is equivalent to the installation that would be needed for a fair-sized community.

The *Malolo* will carry more than 650 first-class passengers; and all the quarters provided for those travelers, as well as for the crew, will be linked up with the general telephone system. Besides this general system there is a separate telephone service for the operation of the ship. In all, there will be in excess of 500 telephones, with a 340-line switchboard; and 4 miles of bridle wire and nearly a mile of lead-covered cable will be needed. Trunk lines will also be furnished so that the vessel can be connected to shore telephones when in dock.



In the machine shop many of the chucks are operated pneumatically to save time and labor.

OIL-ELECTRIC FERRIES FOR SAN FRANCISCO

TO facilitate transportation in the Harbor of San Francisco, the Golden Gate Ferry Company has ordered three Diesel-electric boats to supplement its existing fleet. The new boats will cost approximately $1,325,000. These thoroughly modern craft will be 240 feet long, and each vessel will be able to carry 85 automobiles and hundreds of passengers at a time. The boats will be of the double-ended type; and the primary source of power in each craft will be three Ingersoll-Rand, solid-injection oil engines—each engine being capable of developing 400 B.H.P.

Each oil engine will be direct connected to a Westinghouse generator and exciter; and the current produced by the generators will be fed to two propelling motors—one located aft and the other forward. Like other oil-electric vessels, the motion of the propellers will be controlled directly from the pilot house, thus making it possible for the man at the wheel to maneuver the craft without the aid of anyone in the engine-room.

The oil engines selected by the Golden Gate Ferry Company are of the same type as those recently purchased by the Panama Canal Commission, the Atlantic Refining Company, and the Long Island Railroad Company for the Diesel-electric propulsion of some of their vessels.

Lessening the Noise of the Locomotive

By THE STAFF

ORIGINALLY conceived and developed as a war device, the Maxim silencer, which muffles the explosion of firearms, is now used more and more to reduce nerve-wracking industrial noises. Eight great American railroad systems have adopted the silencer for use in connection with oil-electric locomotives so as to do away with much of the strident sound that for 100 years has been accepted as a necessary evil in connection with locomotives generally. This new application of the silencer was developed for the oil engines, manufactured by the Ingersoll-Rand Company, which drive electric generators on the locomotives in question. Industrialists and public officials the country over are observing the effect of the silencer in this capacity with much interest and with the thought of its more widespread employment throughout the country.

To adapt the silencer to the oil-electric locomotive, even though involving no change in the basic principle of the invention, called for essential modifications in its mechanism. This took months of laboratory work; but the silencer, as now perfected, actually does the work planned for it. Nestling atop the oil-electric locomotive, the silencer traps the escaping engine exhaust without interfering with the release of gases into the atmosphere. In the case of the automobile muffler, the exhaust passes through obstructions, or suffers one or more reversals. In the silencer, as installed on the oil-electric locomotive, the exhaust passes through the silencing unit without reversals and without encountering obstructions.

The noise of the engine exhaust is reflected many times in the silencing unit, the proportions of which have been so mathematically worked out that the energy of the sound wave is absorbed before it reaches the outlet. In fact, so effective is the silencer that the noise of the exhaust may be heard only faintly when standing within a dozen feet of the locomotive.

By muffling the sound in this way it is possible for an oil-electric locomotive to speed along the rails well-nigh noiselessly. In short, so equipped, it can glide through cities or into terminals with no sonorous puffing of engine, no hissing of steam or clamorous rumble. Thus, through the use of what was originally conceived as a war device, the oil-electric has become a silent locomotive—a locomotive proclaiming a new day in railroading.

Twenty-five years ago, Dr. Clarence Blake, noted Boston neurologist, wrote: "If the noise of our cities is to continue, we shall become a deaf nation." In that day, the roar of city life was largely looked upon as something unavoidable, a necessary evil of modern activities. If one must have quiet, there was the country. Since that time people have come to think differently about the matter. Medical men have pointed to the many nerve-worn patients that are in hospitals simply because the deafening din in which they had to live robbed them of sleep and of the quiet necessary to relaxation. Industry, in the meantime, has found that noise injures the nervous system and ofttimes the hearing of workers, aside from lowering their efficiency.

Economists have calculated that the elimination of noise in industry would save the country's manufacturers many hundreds of millions of dollars a year by reason of the increased efficiency of the workers. Records of causes of absence from work show that a large percentage of it is due to the harmful effect of noise on nerves and hearing.

The appearance of the Maxim silencer in industry comes at a time when there is great need for it and when the municipal authorities of various large American cities are investigating ways and means of preventing noise, especially at railroad terminals located, as they so often are, in the midst of crowded office buildings or residential sections.

The Maxim silencer that has made the exhaust of the oil-electric locomotive nearly noiseless.

PROMOTING CANADA'S PAPER INDUSTRY

RECOGNIZING that advance in any industry depends to a great extent on scientific research, there has recently been brought about a merger of interests that will do much to promote Canada's pulp and paper industry. Instead of working separately, as they have in the past, McGill University, the Forests Products Laboratories, and the Canadian Pulp and Paper Association have combined with the object of centralizing research work.

This pooling of interests is largely attributable to the action of members of the Canadian Pulp and Paper Association in subscribing the sum of $350,000—the money to be spent in the erection of a substantial building that is to house the executive offices of the organization and laboratories suitably equipped to carry on experimental work with pulp, paper, and artificial silk.

The university, it is said, will work upon the more fundamental problems on which the ultimate progress of the industry must depend; the Forests Products Laboratories are to represent the field of experimental research —they are to apply the findings of the fundamental workers to the specific conditions of the industry in Canada; and the Pulp and Paper Association will put to practice the findings of the experimental laboratories — the result of the work to be made known for the benefit of the industry.

As six of the nine provinces in the Dominion now produce either pulp or paper, it can be readily appreciated that the collaboration of these organizations—all working to the same end—is bound to be of inestimable value to Canada's leading industry.

A gas plant at Zwickau, Germany, supplies that city, of 80,000 inhabitants, and 12 neighboring communities, having a population of 90,000, with gas distributed under high pressure through 28 miles of pipe lines. Where local tanks are filled from the main line, regulators are employed. A volume of 105,940,000 cubic feet is transmitted annually.

Spray Gun Used to Advantage in the Work of Refinishing Automobiles

By E. E. JOHNSON

CONTRARY to the accepted attitude of the buying public towards something new, the motor-car owner is not conservative. He trades in his car, while it still has years of serviceable life ahead of it, for the latest model with all the newest wrinkles. He keeps pace with improvements in tires, brakes, chassis construction—in short, with any and everything that has to do either with the outside or the inside of a car. For instance, he is as fussy about the exterior finish of his car as a woman is about the polish on her mahogany furniture.

Equipment used in the spraying process employed in repainting or recoating automobiles.

Exposed as automobiles naturally are to all sorts of weather, it has been something of a problem to provide a surfacing material that would be unimpaired by the dust of the road, stand up under severe temperature changes—in brief, retain a high luster months running with just ordinary washing and polishing. These conditions have all been met by various new lacquer finishes—such as "Duco," "Opex," "Murcote," "Pyroxylin," etc.—that are the outcome of extensive laboratory research work which began when automobiles became an everyday necessity instead of a sporting luxury.

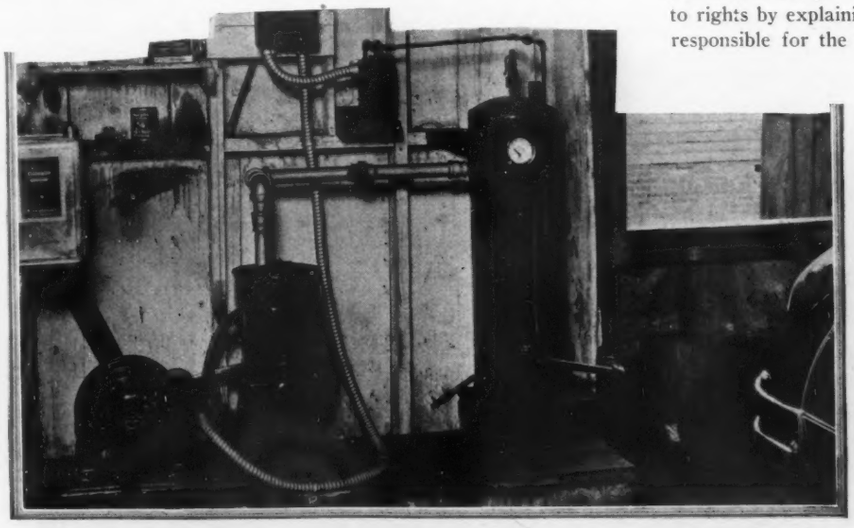
Now one may ask, just what are these new lacquer finishes? Take "Duco," for example, which is conceded to be as much of a triumph of the chemical industry as Bakelite, pyrex, tantalum, crodon, and permalloy. Briefly, "Duco" is a solution which dries so quickly because of the evaporation of the volatile constituents that it is necessary to apply it by means of a spray gun instead of a brush. Ordinary finishes dry by oxidation—the process of oxidation continuing over long periods and constituting a protracted breaking down of the original film. "Duco" is made from cotton, which is first purified by steam and caustic soda and then nitrated by soaking the cotton for a suitable length of time in a mixture of acids, the controlling one being nitric acid. The resultant product is known as nitrocellulose.

This material, to assure ease of application, is next rendered both smooth and fluid by dissolving it in a suitable combination of solvents —such as acetone, amyl acetate, or methyl alcohol, resulting in a transparent pyroxylin liquid. To this fluid mass are then added pigments, softeners or plasticizers, and gums—the softeners assuring the desired measure of toughness and the gums giving the film of lacquer consistency and adhesiveness.

Lacquers of this description are today widely used in the automobile industry. Besides having satisfactorily met the rigid requirements imposed by service conditions, they are easy to apply—a consideration of no small importance in view of the steadily increasing number of cars used in this country. The primary purpose of this article is to deal not with the finishing but with the refinishing of cars with lacquers applied by the aid of compressed air.

To obtain first-hand information on this subject, let us visit an up-to-date refinishing station where we will find a number of cars in various stages of renovation. We see them raised on blocks, with tires, wheels, and fenders removed; and an odor of bananas permeates the atmosphere. Whence the smell? We know that Tony and his banana cart are several blocks away. But our guide soon puts us to rights by explaining that acetate solvents are responsible for the banana odor. He leads us to the department where the automobile starts its journey of rehabilitation.

Each car must undergo stripping—that is, the tires, wheels, and fenders are first removed. Radiator hoods are taken off and laid on a raised bench. If the car be an open one, the curtain studs are taken off. In the case of closed cars, the doors are lifted off the hinges, the handles are unscrewed, and the body is bared to the splash pan. All windows are closed and covered with stiff paper, which is



This plant provides the compressed air used in spraying the coating or finishing materials on automobiles.

fastened by strips of gummed paper. Soft soap can also be used to cover the windows. Upholstery is likewise carefully covered to avoid soiling.

The next step in the operation is the removal of all old paint or varnish, grease, and dirt. Then the metal is given a thorough cleaning. If a car have a baked-enamel finish, this finish is sometimes left on; but the usual practice is to get rid of all evidence of old paint before putting on lacquer finishes. For this work a paint and varnish remover is used. This quickly softens the varnish, which is peeled off with a putty knife. When the last trace of varnish has disappeared, the body is sandpapered until it has a bright metallic luster. The sandpaper employed is of a rough grade and is moistened with gasoline. After being wiped dry with soft cheesecloth, the surface is then cleaned by means of an air-driven buffer brush which adds to the already high luster. All corners, grooves, etc., are cleaned with a jet of air from a blow gun. To make sure that the metal is clean, the body is washed with a thinner. If the thinner evaporate promptly the surface is known to be clean. Spots that dry slowly are washed with high-test gasoline, after which the thinner is again applied. Lacquer finishes require a cleaner surface than when paint and varnish are used. Now the car is ready for the primer or undercoats.

The undercoats usually consist of a metal primer, a putty glaze, and a surfacer, applied in the order given. The primer may be of any color, and is sprayed on with air at a pressure of from 30 to 40 pounds. After the primer has been allowed to dry for 24 hours the surface is again sanded until it is smooth enough to receive the surfacer coat. Putty glaze is used to smooth out file marks or rough places —the putty being worked on in thin layers, each of which is sanded after having been given ample time to dry. The surfacer or filler coat is then sprayed on, using air at a higher pressure owing to the difference in the specific gravity of the fluids. Five or six coats of surfacer are applied, depending on the condition of the metal body; and about 6 hours are allowed for drying between applications.

After the last coat of surfacer has dried, the body is rubbed smooth with sandpaper, moistened with water, or with pumice stone and water. As this is the last stage before the application of the color coats, the surface must be smooth and thoroughly dry. In the booth to which we were shown was a Cadillac car ready to receive the color coats. As fast as one coat dries another is applied—about six coats of "Duco" being needed to do a satisfactory job. Owing to the lower specific gravity of the material, the finishing coats are applied with air at a lower pressure than that required for the base coats. Care must be exercised in using the spray gun to assure a uniform layer of lacquer with each sweep of the gun. Otherwise, so called spray waves are produced that may mean many unpleasant hours of rubbing to obliterate them.

The operator holds the spray gun about 6 to 8 inches away from the car and at a slight angle, the nozzle pointing upward. He always works lengthwise, going from the front to the back of the car or *vice versa,* and brings the spray so close together that the lacquer overlaps. One hour drying time is allowed between coats—the last coat being a mist coat which acts as a leveler to produce a smooth surface. After drying, the surface is rubbed with a suitable polish that gives the desired glossy effect.

As the various coats are now commonly applied by the spray method, this article would not be complete without some mention of the compressor and the spray gun, which are important parts of the equipment of a refinishing shop. In this case we found installed a small Ingersoll-Rand, electric-motor-driven unit of the vertical, single-stage, single-acting, self-oiling type with enclosed center crank. Because of its reliability and accessibility, apart from the automatic start- and stop-control feature, this machine is especially adapted to auto-refinishing service.

This small type of compressor embodies a 3-piece piston ring and an oil-wiper ring, which insures maximum economy in the use of oil. The air supplied by this machine is free from oil, something that is quite necessary in work of this kind. To still further insure clean air, there was provided an air-conditioning unit—a combination oil-and-water extractor. When air is not clean the result is defective work; but by the aid of an air-conditioning unit all traces of oil, water, or other foreign materials can be removed before the air reaches the spray gun.

The spray gun, of which several different makes are on the market, is deserving of description. To do effective work, a gun of this type must possess certain features, such as: complete atomization of the fluid immediately upon reaching the outlet of the nozzle; straight air passages to facilitate cleaning; simplicity of gun control; and ease of handling. Furthermore, a spray gun must be able to produce a flat fan-form of spray, varying in thickness, and a round spray capable of being narrowed down to a diameter of 1/8 inch or smaller for retouching or special needs.

The pressure containers used with the spray gun differ according to the work to be performed. For touching up, for doing patch-work, and for painting the chassis, wheels, underneath fenders, etc., pint cups of spun copper are screwed onto the gun. These, because of their size, do not lend themselves to body finishing. In the shop visited, the container provided for this purpose has a capacity of from 2 to 5 gallons, and consists of a heavy steel shell—with a removable head of cast iron —equipped with two pressure regulators, gages, and a relief valve. The operator is thus able to control the pressure of the air and to regulate the flow of the fluid regardless of its viscosity or its gravity.

The coal mine having the best record in the United States Bureau of Mines National Safety Competition for the bronze trophy presented by The Explosives Engineer magazine was the Upper Lehigh Colliery of the Hazle Brook Coal Company, Upper Lehigh, Pa. Our picture shows the superintendent of the mine, Mr. D. W. Muir, distributing certificates to a carload of miners coming up at the end of a shift. Each employee of the colliery received one of these certificates of honor duly signed by the Director of the United States Bureau of Mines.

Following the process as we have, step by step, it may appear to the reader as somewhat long drawn out. But it is not, in fact, because of the ease and the speed with which the layers are applied by the paint spray. The average car can be refinished in five days' time, but in a shop of medium size it takes about ten days to do a first-class job. And by a first-class job is meant a beautiful, glossy finish of unusual lasting qualities—a finish that mellows with age, that is hard and tough, and that will not crack, check, or peel.

American-Made Dolls For American Children

Amazing Growth of This Industry Another Example of What Native Ingenuity Can Accomplish Despite Heavy Odds

By JOHN N. WHITEHOUSE

LITTLE Miss America, the bewitching doll that is winning its way into the hearts of so many children, typifies our native ingenuity; and the progress of the industry that has made this product possible is scarcely equalled—certainly not surpassed—by any other example of manufacturing growth. This development can be better realized if we recall that dollmaking, as a department of manufacturing, was virtually unknown in this country but a few years back.

As recently as 1910, the making of dolls in the United States was confined to a limited number of specialties—freaks, such as Kewpie dolls and the like—handled exclusively at fairs and carnivals and given away for the most part as premiums at shooting galleries, etc. Almost all the dolls used as playthings were then imported—most of them coming from Germany and France.

When the war broke out, the necessity of providing the American child with a doll became a puzzling problem, and a rush was made by a number of people in the floating novelty line to meet the growing demand. The importer was disposing of his stock at fabulous prices. Manufacturers popped up like mushrooms, producing the most impossible looking freaks under the heading of dolls, and selling them. This brought American ingenuity to the surface; and in a few years made the United States a head liner in an industry in which other countries had been engaged for hundreds of years.

© White Studio.

Little Miss American, made here to delight American children.

It is interesting to note that one of the pioneers in the doll business, and without a doubt the most outstanding figure in the work achieved in this country, was a woman, Madame Hendren. It was she who perfected the soft-bodied doll in which it is possible to embed mechanical devices. Hence the famous American "mamma doll." Previously, most foreign dolls had been made of various compositions, and their component parts were held together by elastic. Their heads of bisque—a cross between clay and porcelain—were easily breakable, but strong enough to injure a child. These have been supplanted by an unbreakable head, an American product, that has not only superseded the European bisque head in this country but is rapidly being taken up in England, Germany, and Canada.

Unbreakable heads, as well as legs and arms, are pressed out of sawdust—a composition originally created by French governmental laboratories in an effort to produce synthetic wood. The composition consists of powdered wood and starch, mixed with water, and of a small percentage of rosin which acts as a lubricant to prevent the material from sticking to hot molds. This mixture is placed in bronze forms, heated to about 400°F., and left to bake for five minutes. When the heads, legs, and arms—which come in halves—are removed from the molds they are glued together and dried. After this they are ready for the sandpapering of the

Left—The typically up-to-date doll factory boasts its own dressmaking department where frocks and other togs dear to childhood are produced in endless varieties.
Right—In a way, this is a beauty shop, because here it is that the wigs are mounted on the heads and the hair is dressed in the latest babyhood styles by experts.

After the two parts that form each leg, arm, and head are glued together, then the junction seam is obliterated by sandpapering, which is done carefully by hand.

seams. This is an important operation, as the shape of the article is apt to be disfigured by the sandpaper if handled carelessly. Men engaged in this work sit at low benches so as to have a good view of the articles before them; and they rub each and every part by hand until the seam is no longer visible. The parts are now ready to receive the finishing touches, and here is where compressed air is indispensable.

Because of the composition used, the heads, legs, and arms are somewhat porous and have a rough surface. To cover up the imperfections left after baking and sandpapering, each piece is given a thick flesh-colored coating composed of a mixture of glue and other ingredients. In the case of the heads, a layer of bright red is next applied to the cheeks with an air spray; and by means of compressed air, at a higher pressure, the entire head is then covered with a translucent, flesh-colored, guncotton solution. This top coat allows the cheek tints to show through, producing a blended hue that is lifelike in appearance. Once more the air spray is brought into play when "hair" is blown onto those heads that are not finished with wigs, such as baby heads.

While the doll body is in the process of making, another group is busy designing and sewing dresses. For a time, during the development of the industry, manufacturers of children's dresses provided the clothing for the dollmaker. But as the trade grew, a number of the dress producers began to fabricate dolls, and the dollmakers, in turn, to make dresses for their own needs. This part of the business is an art in itself, and calls for as much if not more creative skill, beauty, and taste as are required in the regular dress line where style is often the first consideration. There is no particular style in doll dresses: the manufacturers simply fashion prettier designs from year to year.

One of our illustrations shows a part of the dressmaking establishment of a modern doll shop. There, all sorts of dresses—each requiring a different pattern and design—are sewed for infant dolls, for talking dolls, and for walking dolls from all kinds of materials ranging from the plainest fabrics to the most expensive satins, silks, ribbons, and laces. Miniature stockings are especially made for the trade. The manufacture of shoes is also a separate industry. For a long time after quantity production had been attained doll shoes were still supplied from foreign sources. Only in the last few years has the doll shoemaker come into being here and taken the place of the importer. In 1925, the number of shoes produced in this country reached an average of 35,000 pairs daily.

Dolls' hands, which in some cases are jointed so that they move separately in the arm, are made of celluloid. Here, again, compressed air has a function to perform. Two sheets of celluloid are placed between a 2-piece mold of bronze. A number of these forms are put into a hydraulic press and heated, thus rendering the celluloid plastic. The pressure exerted by the press tends to keep the sheets together, while a blast of air, blown through a small opening between the two sheets, forces the material to assume the contours of the mold—at the same time uniting the edges. Before the pressure is released the molds and their contents are cooled. The hands, as they come from these molds, are in their finished form, already colored, and are light and firm.

Another branch industry which just naturally developed is that of wig making. At present, dollmakers are supplied with wigs of a variety of shapes and colors. And, as is to be expected—following the mandate of fashion, long curls are rapidly being replaced by bobbed hair. The wigs come in different sizes to fit the heads; and they are glued on by girls. These girls are expert hairdressers, and comb, curl, and beribbon the heads of the dolls with as much art and dexterity as a Fifth Avenue hairdresser might display.

There are two types of dolls' heads, those with painted eyes and those with moving eyes for sleeping dolls. In the case of painted eyes, the eyebrows, lashes, iris, and pupils are tastefully done by hand, with small brushes, in brown or blue, as the complexion of the doll may require; and in this work are engaged commercial artists that do the painting with amazing rapidity, not to mention skill. The moving eye is a more complicated thing, and for that reason fewer sleeping dolls have been put on the market. In fact, until recently, not more than 15 per cent. of the dolls made in this country had eyes that could open and shut. Within the last two years, however, there has been a greater demand for them, which has brought the percentage of sleeping dolls up to about 40; and the prospects are that it is only a matter of time when all dolls will be fitted with moving eyes.

Formerly, the Germans were the past masters in the art, and virtually controlled the article.

In this department the bodies and the flexible connections of the limbs are stuffed to give them the desired childish plumpness.

Photos, Averill Manufacturing Company.

Fig. 1—In these presses are produced the unbreakable parts which now distinguish the best of American-made dolls.
Fig. 2—Nimble-fingered workers glue together the two parts which form each head, arm, and leg.
Fig. 3—These men are engaged either in painting eyes or in inserting eyes that will open and close.
Fig. 4—The dipping process by which the non-breakable parts are given a thick flesh-colored coating composed of glue and other ingredients.
Fig. 5—Compressed air is used in this department to spray color on the cheeks and to cover the entire head afterwards with a translucent, flesh-colored, guncotton solution.

The eyes they produced were made out of glass, blown and painted by hand—the paint being burned into the glass just as is done in the case of glass eyes for human beings. This industry, unfamiliar to us, was confined to certain sections of Germany, where the business was handed down from father to son—kept in the family, so to speak. For those and other reasons, it looked for a time as though we were up against it when we were confronted with the problem of making eyes for sleeping dolls. Here is where American resourcefulness came to the rescue.

Hand-made glass eyes have been replaced by celluloid eyes. The designs are lithographed onto a sheet of white celluloid, which is covered with a transparent sheet of the same material to give the iris depth. Being a machine-made article, these eyes are far more satisfactory for a number of reasons: First, the shapes and sizes can be controlled; second, they are not glassy in appearance; third, they do not break in handling; and, fourth, after they are once placed in the head they are well-nigh indestructible.

Here the dolls are skillfully dressed and given that touch which makes them so appealing to the young and the old.

The stuffing of the body is a somewhat primitive operation. Bales of cotton are especially prepared for the purpose. The legs, upper arms, and bodies are sewed into shape, and then cotton is forced into them through a tin funnel until the required form is obtained. At this stage much depends on the skill of the worker, who decides whether or not the doll is well shaped. An accompanying picture shows how clean the stuffing room is kept in a modern plant. The numerous parts being finished they are ready for assembling.

Now comes the final and the most important operation: the dressing of the dolls. Although the dressers follow the original plan of the designer, a carelessly placed garment or a badly tied bow of ribbon might disfigure an otherwise beautiful doll. The girls employed for this work must have as strong a liking for dolls as a successful nurse has for the children she takes care of. In other words, a doll dresser, to be efficient, must have a natural liking for dolls.

The commercial aspect of the industry offers as many intricate problems as does the technical side of the business. Many of the pioneers that failed before the eccentricities of the buying public in this particular line had been recognized and satisfactorily met proved to be what might be called stepping stones for the survivors. Each and every industry has its own laws, its own customs. These cannot be followed except in part in taking up a new business. It might seem natural for those well established in trade to label the man who errs as incompetent; but unexpected conditions are apt to arise in promoting a new line of effort that even the most farsighted cannot foretell. For example, distributors of dolls are mostly located in busy sections of a town where they must pay high rentals. This compels economy of space. But dolls are bulky, and occupy more room per square foot to the dollar than most of the other merchandise handled under the same roof. In addition, the article is a so-called holiday item—the greater share of the business with the ultimate consumer occurring in the last month of the year. As the distributor's costly space forbids him to carry stock in the dull season, the dolls generally have to be made within a period of three or four months each year. In the early days of the industry, the makers that were not in a position to work the year round and to carry the financial burden found themselves rushed with orders at the end of the year. As a result, the largest part of their production was made with overtime; and, when the season closed, they found a deficit where there should have been a profit, according to their calculations.

Another incalculable item was that of labor turnover. Each of the ten major operations involved in producing a doll requires a certain amount of skill. As the trade was new, all this work had to be handled by apprentices; and the amount of merchandise that had to be disposed of as seconds ate up all the profits. Failure after failure was recorded, so that the doll business was classified as a bad risk by bankers and raw-material supply people. Such were some of the conditions that the pioneers in the trade had to meet. They may have figured all that the average business man is accustomed to figuring; but in a good many cases they hit unexpected snags that turned the course of business into losing channels.

It was a foregone conclusion that we were out of the race with foreign competitors at the end of the war. After armistice day, every department-store buyer of toys returned from Europe armed with connections with foreign doll manufacturers, and every distributor placed orders with foreign firms. Paradoxical as it may sound, this helped to put the domestic industry on a firm basis. Just at that time the German mark went to pieces, and with it the German business morale. Merchandise landed in this country not only in a most unsatisfactory condition but late. This created confusion, and many distributors were left without sufficient goods to meet the demands made upon them. Then it was that our people awoke to the fact that the American doll was more than a match for the European doll; the keen eye of capital was attracted; and a new era of production on a systematic basis was begun. Their annual demand estimated, manufacturers started year-round work. It gave them an opportunity not only to figure their costs accurately but it enabled them to assure the workmen steady employment.

The trade is still limping under the yoke of overpaid labor. Not to be misunderstood, let me explain. The average doll worker is a semi-skilled mechanic, a cross between a day laborer and a skilled worker. Most of the operations can be mastered after a few weeks practice, and yet the average doll worker earns more than a machinist or a toolmaker, whose time of apprenticeship runs into years. But this is rapidly being equalized by year-round production to the satisfaction of both employer and employee. The small manufacturer still works under the old system: he usually closes up shop from the middle of December until about May. Beyond preparing his samples he does little or nothing. It is this unstableness that at times throws the cost of labor out of all proportion, as compared with other trades.

It might appear to the lay mind that there is no keen competition in an infant industry. But there is competition; and it is caused mostly by our typical American way of retailing, which is contrary to the custom of selling prevailing in the old country where "between prices" are unknown. Our retailer sells for 5 cents, 10 cents, 25 cents, 50 cents, $1, and so on. The reaction to this method of selling is self-competition, as expressed in the accepted economic proverb that a hat is worth five dollars and five dollars is worth a hat. Namely, five dollars is

a definite unit; it does not fluctuate. However, for five dollars the maker might offer you a better hat today than he did yesterday, and a still better one tomorrow. This is the keenest competition that the dollmaker has to face. He may offer a buyer a doll which, judged by size and general appearance, is classified as a dollar doll. The next time the buyer calls he may find that the doll is still in the dollar class even though improved in size and beauty. That is self-competition—a healthy condition that indirectly promotes efficiency, and is responsible for much of the remarkable development in the domestic doll industry.

The trade, as it exists today, has one exhibition in New York and one in Chicago at the beginning of each season. Just how extensive these exhibits are can be appreciated when it is understood that almost every room in one or other of the prominent hotels in these cities is rented by the different manufacturers for the display of their new goods. No fewer than 53 New York manufacturers participated in the last doll show; and the value of the combined production in 1925 reached the sum of $18,000,000—an impressive amount for an infant industry.

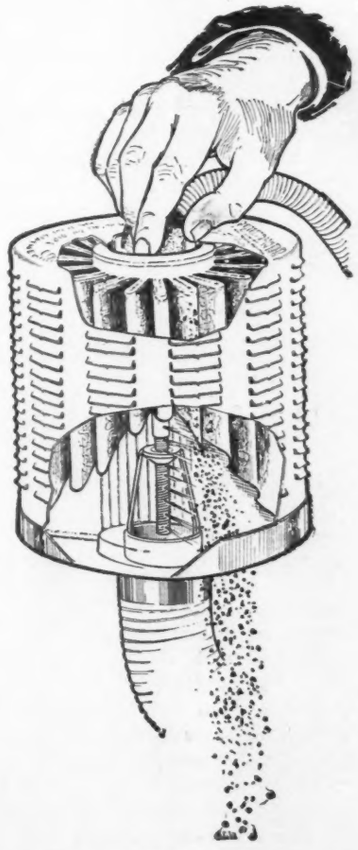
The meaning of this development of America's doll industry is made clearer when it is recalled that one manufacturer, a few years ago, feared that we were on the eve of overproduction because the output at that time was valued at $10,000,000. As a matter of fact, when the American child fully realizes what American factories have to offer in the way of better dolls than those from foreign sources, the business or the industry—call it what you will—will be much bigger than it is today. Indeed, it will probably be a matter of only a short while before our manufacturers will be formidable competitors in foreign markets.

IMPROVED AIR FILTER FOR MOTOR CARS

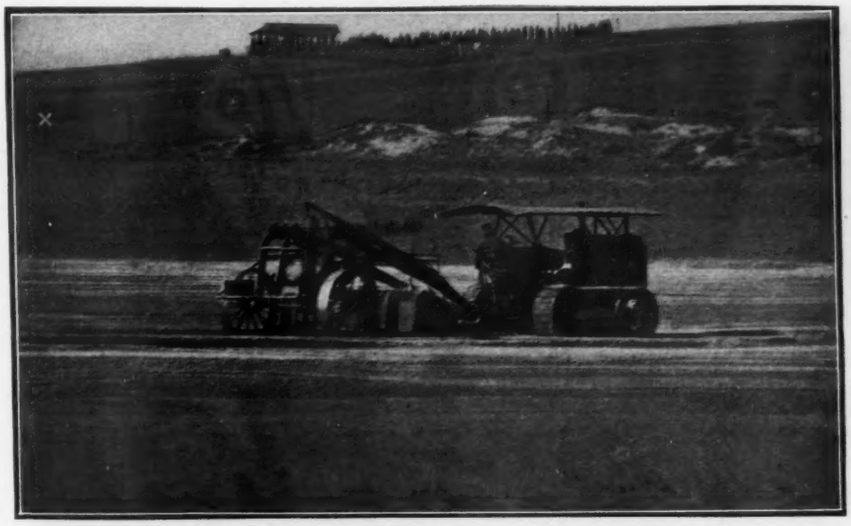
ROAD dust encountered in driving automobiles is costing the American motorist $1,000,000,000 annually, says a writer in a recent issue of *Motor*. Be this as it may, dust is found in large quantities in the carbon deposited, and it is responsible for much of the wear and tear on valves, bearings, and cylinder walls. In short, dust is the source of many automobile repair bills. To offset this heavy expenditure, numerous air filters have been devised; and an improvement recently made in one of these should be of interest to the motoring public.

The "Protectomotor" air filter, manufactured by the Staynew Filter Corporation of Rochester, N. Y., is now so constructed that it can be easily cleaned of any contained dust or grit by a blast of air. To effect this, the top of the tubular retaining bolt—to which the felt fiber medium is secured—is arranged to receive the "free-air" hose to be found in the average garage; and, in order to permit the air to escape or to reach the fiber, the bolt is perforated.

According to the manufacturer: "About once every three months a tire hose should be applied to the top of the bolt, which is revolved as the air is forced through it. Each individual fin of the felt fiber medium is exposed to the full force of the blast of compressed air. The dust collected on the outer surface of the felt is thus blown off, leaving the large area of filter medium clean and porous."



Improved type of air filter for motor cars. This filter can be easily cleaned by a jet of compressed air from the "free-air" hose found in the average garage.



The scraper of the land leveler, attached to the tractor, is raised or lowered by means of a piston moved with compressed air provided by the caterpillar tractor.

AIR-OPERATED SCRAPER USED TO LEVEL DUNES

WHEN the wind blows in from the Pacific Ocean it tends to pile sand into high dunes along certain stretches of the California coast. Picturesque as these sand hills are, they make the land so covered worthless as a real-estate proposition; but when it is piled up upon popular bathing beaches it pays the proprietors to have the undulating waves of sand flattened out or leveled.

That is just what is being done; and the machinery used for the purpose consists of a caterpillar tractor equipped with a land leveler. The leveler, which is towed by the tractor, is controlled by the driver from his station at the wheel; and compressed air is the medium employed to operate the leveler. The necessary compressed air is carried in a tank attached to the rear of the leveler. This tank is connected with the tractor motor by an air hose. Just to the driver's left is a 2-way valve which either permits the release of air for the operation of the leveler or the passage of free air into the tank—the motor furnishing the power for the compression of the air.

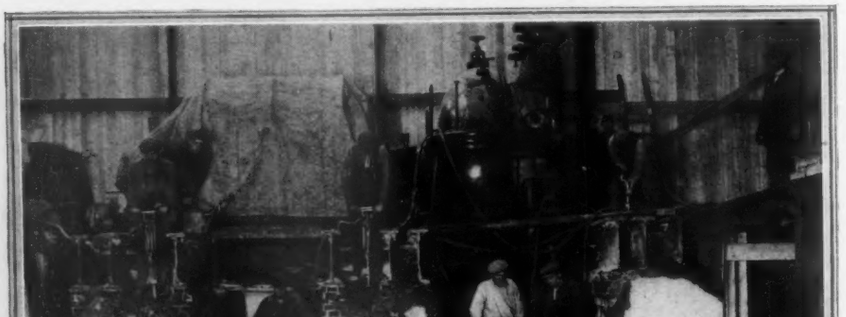
When it is desired to lower the leveler in its frame, air is released—the pressure forcing the scraper down. When full force is appplied, the pressure is sufficient to lift the wheels of the leveler so that the scraper rests bodily on the ground. Conversely, a reduction in pressure allows the scraper to rise and to resume its normal position. In reclaiming a certain stretch of beach, not long ago, two such land levelers shifted 900,000 cubic yards of sand; and in this work they were called upon to fill cuts from 25 to 30 feet deep.

There has been opened in India a school of mines that is fully equipped and staffed for high-grade instruction in mining engineering and geology. The school is at Dhanbad, and close to the Jharia coalfield—the most important colliery in India.

DEMOLISHING HEAVY FOUNDATIONS

By G. L. STUYVENBERG

ON account of an increasing demand for electric power, the Electricity Works in The Hague, Holland, was recently confronted with the problem of installing larger turbo-generator sets. In order to make room for the bigger machines it was necessary to remove some of the small existing turbo-generators; and this called for the demolition of the foundations of the old turbo-blowers, as well as a certain portion of the floor—in all approximately 525 cubic yards of material.



Air-operated paving breakers made comparatively short work of demolishing the foundations of old turbo-blowers in order to make room for setting up larger machines.

Inasmuch as the work had to be done in the shortest possible time, the engineers of the Electricity Works first set about determining how best to break out the stonework so that the service of the plant would be interfered with as little as possible. After due deliberation, the management decided on the use of air-driven equipment—CC-25 paving breakers with which the company had previously had some experience in doing other demolition work.

Five paving breakers of the type in question were promptly secured, as well as an I-R, Type 20, gasoline-engine-driven portable. This compressor, in combination with an electrically driven portable that was a part of the plant's equipment, furnished all the air for operating the paving breakers. So that the prosecution of the work might not be interfered with in case of a breakdown of the power plant, another Type 20 portable compressor was provided as a stand-by.

Each portable compressor of course had its own receiver; but to centralize the air supply for all the tools the engineers installed a large receiver with which all the compressors were connected. A common air line was then led to the point where the work of destruction was to be done. In laying this air line it was necessary to break through a wall about 30 inches thick. By the use of a BCR-430 "Jackhamer" this opening was made in the amazingly short span of 15 minutes.

The work in hand was accomplished without experiencing any trouble either with the tools or with the compressors; and the length of time taken to complete the job justified the selection of the equipment by the engineers. Some idea of what was involved in enlarging the capacity of the plant is given by an accompanying photograph, which also shows that the wrecking of the foundation was begun before the removal of one of the alternators.

These portable compressors furnished the operating air for the paving breakers that demolished the foundations of the discarded turbo-blowers.

STUDYING THE EFFECTS OF HEAT ON WORKERS

THE United States Bureau of Mines and the United States Public Health Service have recently collaborated with the Society of Heating and Ventilating Engineers in an effort to determine how much heat a worker could endure without suffering any ill effects. As a result of the tests made, many time-honored ideas have been shattered and facts and figures have been arrived at that stress the importance of maintaining proper atmospheric conditions in factories, foundries, mines, etc. The tests were conducted with human beings and in laboratories and scientifically constructed rooms in which were simulated prevailing industrial conditions.

Perhaps the most interesting finding made by the investigators was the fact that a robust man, stripped to the waist, would remain normal for an indefinite period even though working in an atmosphere registering 90°F., and 100 per cent. relative humidity. The man's endurance, of course, decreased in proportion to the intensity of his physical labors. Another test proved that the consumption of large quantities of ice water by workers subjected to great heat was, in no case, harmful. In fact, several of the men, after long exposure to high temperature and exertion, drank as much as a quart of ice water in 15 minutes without any ill effects.

It is commonly known that many industrial workers suffer from an eye disease called conjunctivitis. Experiments revealed that perspiration entering the eye was responsible for the disease. It was found that a small quantity of sweat, dropped into the eye when normal, caused the organ to become sore and inflamed. Although perspiration from the chest and the arms was discovered to be more injurious than that from the face or forehead, the experimenters recommend that workers who are subjected to great heat be provided with sweat bands to be worn above the eyes.

A strike of very rich gold ore is reported to have been made between Argentine Pass and Montezuma, in the Sheep Mountain district of Colorado. It is said that the property will be energetically exploited next spring.

Tata Hydro-Electric Project

This Magnificent Undertaking Supplies Energizing Current to Many of Bombay's Industrial Plants

By R. HUNTER BRIGGS

BRITISH India, with nearly 319,000,000 inhabitants, is awakening industrially. Though primarily an agricultural nation, about 16 per cent. of her population, or some 52,000,000 people, are now engaged in industry. Textile weaving is the leading gainful occupation, at which approximately 800,000 organized workers, in about 3,000 factories, are employed. The number of cotton mills has increased from 194 in 1900 to 333 in 1923; and there were more than twice as many jute mills in 1920 as there were in 1900. Furthermore, there were 111,000 persons employed in the jute mills in 1900, but by 1920 the number had grown to 280,000. In addition to those already mentioned, there are other industrial establishments, of more or less importance, such as cotton gins, rice mills, flour mills, sawmills, machine and railway shops, tanneries, mines, etc.

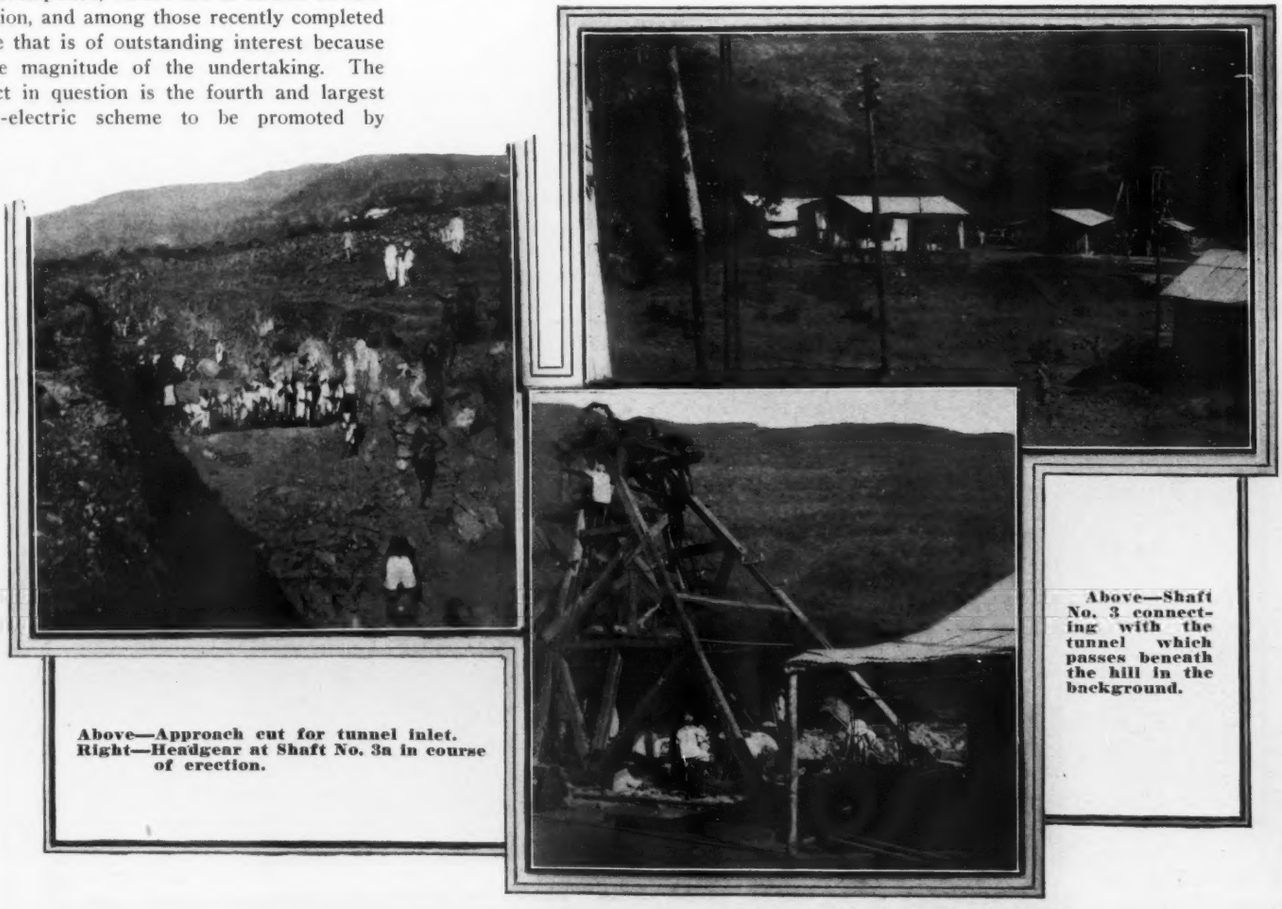
Hand in hand with this industrial expansion, India has been developing her extensive water-power resources in order to supply the steadily increasing demand for electricity. Numerous hydro-electric projects are awaiting development, others are in course of construction, and among those recently completed is one that is of outstanding interest because of the magnitude of the undertaking. The project in question is the fourth and largest hydro-electric scheme to be promoted by Messrs. Tata Sons, Ltd., of Bombay; and the power produced is sent over miles of transmission lines to the City of Bombay where it is used principally to operate railways and tramways, and to run cotton mills. Bombay is now a thriving industrial city, of nearly 1,000,000 inhabitants, in the heart of the textile district. The textile industry, as previously mentioned, ranks first, and makes the greatest demand for power.

FOR centuries, India has been essentially an agricultural country; and her people have suffered woefully when famine and disease followed close upon crop failure. Latterly, however, she has gone in more for manufacture.

This has led to the development of some of her water-power resources; and the present article describes one of the biggest of these undertakings.

The work accomplished is significant in view of the fact that dependence had to be placed upon Oriental labor. The success obtained was undoubtedly due in a large measure to the use of air-driven rock drills and certain other modern equipment.

The Tata Hydro-Electric Project, built at a cost of about $24,000,000, lies in the Western Ghats, which form a great wall directly back of and paralleling the coast of the Bombay Presidency. This mountain range is exposed to the full force of the southwestern monsoon, and has a very heavy rainfall averaging annually 160 inches. In fact, on the outer ridge, the annual rainfall has been known to amount to as much as 300 inches. It was to conserve and to impound this water that it was decided to build a great dam across the Mula River and thus to form a lake, covering an area of 16 square miles. This lake accumulates the run-off of a watershed of 112 square miles.



Above—Approach cut for tunnel inlet. Right—Headgear at Shaft No. 3a in course of erection.

Above—Shaft No. 3 connecting with the tunnel which passes beneath the hill in the background.

Left—Headgear at No. 2 Shaft with chute for shaft sinking.
Right—These sloping tunnels lead from the gate chamber to the main tunnel.

The dam is 4,000 feet long and 150 high at the center; and in its construction there were used 21,000,000 cubic feet of masonry and concrete.

The project also involved the driving of a tunnel under the western ridge of the Western Ghats to carry the impounded waters to a power house located down in the valley. This tunnel is 14,500 feet long, has a cross-sectional area of 140 square feet, and a gradient of 04 per cent. It is with the driving of the tunnel that this article principally deals; but, before giving a detailed account of the work, a brief outline of the generating plant and the transmission line of this important development might prove of interest.

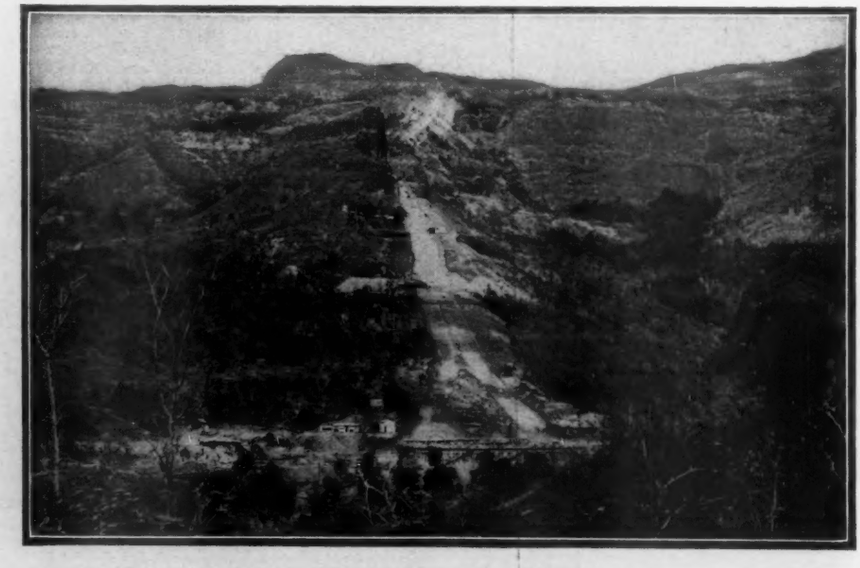
The penstocks carrying the water from the tunnel outlet to the power house consists at the outset of 3 pipes, 7 feet in diameter, which are concreted into the tunnel for a distance of 100 feet. These penstocks branch out into six 4½-foot pipes, and finally terminate in 12 pipes having a diameter of 3 feet. These 12 penstocks have a drop of 1,700 feet in a distance of 6,000 feet, and deliver the water through nozzles to 14 Pelton wheels. Twelve of these Pelton wheels generate 15,000 H.P. each when running at 375 revolutions per minute, while each of the remaining two, when working at 600 revolutions per minute, generate 1,050 H.P. The 12 large wheels, operating in pairs, drive six 21,750 Kv-a. generators which produce 50-cycle current of 11,000 volts when making 375 revolutions per minute, while the two smaller waterwheels are used to drive 500-kilowatt exciters which produce current of 250 volts when making 600 revolutions per minute.

The current generated by the 6 main units is stepped up by means of 12 transformers from 11,000 to 110,000 volts for delivery over the transmission line.

The transmission line consists of two double circuits, 75 miles long, carried on fabricated-steel towers placed about 500 feet apart. This line delivers the current to a receiving and distributing station, situated in the northern part of Bombay, where 12 large transformers, of 9,000 Kv-a. each, step down the current to the voltage required to operate local railways, tramways, mills, etc. According to the last annual report of Messrs. Tata Sons, Ltd., the plant now delivers electric energy to 44 consumers, using 56,000 scheduled horsepower, exclusive of the Bombay Electric Supply & Tramways Company, Ltd.

As some of the accompanying diagrams show, various shafts were sunk along the tunnel line so that the work could be advanced simultaneously from numerous headings. The longest section, between shafts Nos. 3 and 4, had a length of 6,700 feet, and this was necessitated by reason of an intervening high mountain ridge. Special efforts were made to expedite work on this section, and, as a result, it was finished only three weeks later than the last of the other sections. Certain bends in the tunnel had to be made, as indicated on one of the plans, first, to overcome problems that arose in connection with the feeding of the water from the lake to the tunnel inlet, and, second, to provide for more top cover between Shaft No. 4 and the extreme outer ridge.

To supply electric current for driving the air compressors, pumps, and other plant equipment, transmission lines, delivering current of 22,000 volts, were run from the power house of an allied company along the tunnel line and thence to the dam site. By means of substations, placed at various convenient points, the current was stepped down to 2,200 volts for operating the machinery and to 220 volts for lighting and for other minor services. The power supply was, in the main, reliable; but more than once work at the headings had to come to a standstill owing to short circuits caused by birds. Where water occurred, as at the eastern side of the tunnel, supplementary power was essential. This was supplied at three shafts by portable boilers designed to operate the hoists and the pumps if for any reason the electric power failed.



Cut leading up toward the tunnel outlet. Picture taken from an elevation above the site of the power house seen in course of construction in the nearby valley.

On the east side of the ridge, at shafts Nos. 1, 2, 3 and 3a, hoisting engines were installed, but on the west side no hoisting was necessary because the spoils were taken out through adits Nos. 4 and 5 and through the outlet of the # tunnel. Wooden headgear of the ordinary small mine type, about 30 feet high, was erected;

and standard mining-type cages were installed at shafts Nos. 2 and 3a. These cages ran on guides —that is, on 30-pound rails clamped to timbers cemented in hitches in the walls of the shafts. The arrangement proved very satisfactory, and gave no trouble throughout the work.

The pumping plant on the east side consisted of 4 Cameron sinking pumps: two 8x4x12-inch pumps at Shaft No. 2 and two duplex horizontal 6x4x6-inch pumps, one each at shafts Nos. 3 and 3a. These pumps were driven by compressed air and were assisted by two smaller pumps of the boiler-feed type. But even when running at full capacity, these pumps were not capable of holding within the required limits the large amount of water that accumulated during the monsoon period. An electrically driven 5x8-inch, 3-throw pump was therefore added to the plant at Shaft No. 3 to increase the pumping capacity there during the monsoon period.

Power house under construction, with the pipe-line cut shown in the background.

The drilling equipment consisted of Sergeant drills, "Leyner" drills, Ingersoll-Rand "Jackhamers," and telescopic stoping drills. And to insure an ample supply of suitable drill steels, two No. 50 "Leyner" sharpeners, complete with oil furnaces, were available. An air-driven pedestal grinder, for trimming shanks and bits, was also provided. To supply sufficient operating air for the various pneumatic tools and machinery, there were put at convenient points throughout the job six 13x16-inch, Imperial Type "X," duplex compressors, each driven by ten 1¾-inch cables from a 150-H.P. motor. Of these compressors one each was placed at shafts Nos. 1 and 2, and two each at shafts Nos. 3 and 4. Each unit was provided with a cylindrical receiver from which the air was led underground by way of a main 5 inches in diameter. At the tunnel intersections the air was fed from this main through 3-inch piping directly to each working face.

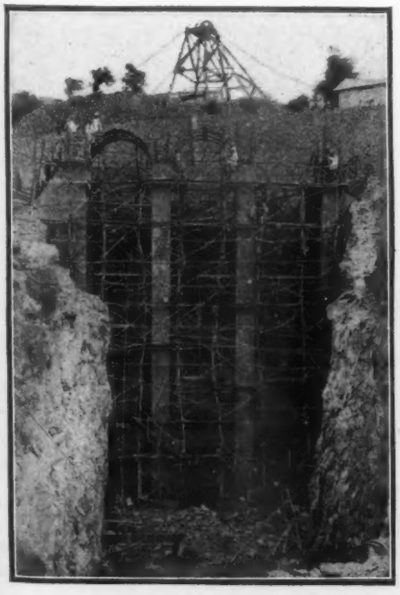
Square end-tipping trucks and V-shaped side-tipping trucks were used for the removal of the spoils. The equipment also included a steam engine with trailers for the transportation of heavy machinery; a steam roller for keeping the roads on the contract in good condition; a pneumatic pick for cutting hitches and to do similar work; air hoists, a scraping shovel, a cement gun, and an electric exploder.

Artificial ventilation had to be resorted to for any length of time only in the long section between shafts Nos. 3 and 4; at the other working faces stimulated ventilation was unnecessary except in one or two cases and then only for short periods. The ventilating machinery consisted of a 3-foot blower, driven by a 20-H. P. direct-coupled motor, delivering air through 18-inch canvas tubing to the points desired. Electric lighting was used throughout the tunnel—the insulated cables supplying the current for this purpose being supported on wooden pegs and held in place by porcelain cleats. Bulbs of 50 candle power were attached at 100-foot intervals—those at the headings being secured to flexible extensions that could easily be shifted before and after each blast. Vibration affected the bulbs considerably; but electric lighting was essential to rapid progress.

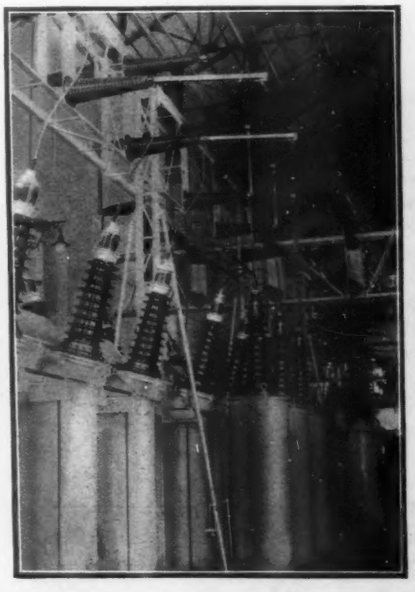
Before the power machinery had been erected, the work of sinking the shafts and of driving the adits was done principally by hand. As the upper parts of the shafts, which were either round or elliptical in form, extended through very porous ground for the first 16 to 50 feet, it was necessary to line those sections with concrete. Afterwards the inner faces were coated by means of the cement gun. In the case of Shaft No. 3a the lining consisted of masonry, in lime mortar, with cement on the outside. The lining kept out most of the surface water and allowed the work to proceed during the monsoon period, something that would otherwise have been quite impossible in a locality with an annual rainfall at times of 300 inches within a span of only 4 months.

Different methods of excavating were employed in driving the tunnel. The height of the tunnel made it impossible to do the work in one operation without the use of staging: and after some experimenting it was found that the method, as illustrated, was the most satisfactory. A bottom heading was tried for some time, the upper bench being removed by telescopic stoping drills. This system had the advantage that the rails could be kept right up to the working face. In other respects, however, it was unsatisfactory, as it did not produce an even roof, and the drilling of the top bench interfered with the removal of the spoils. One contractor tried a top heading extending about 30 feet ahead of the bench, but this caused delay in getting out the bench owing to the necessity of removing the spoils from the heading, itself, by hand.

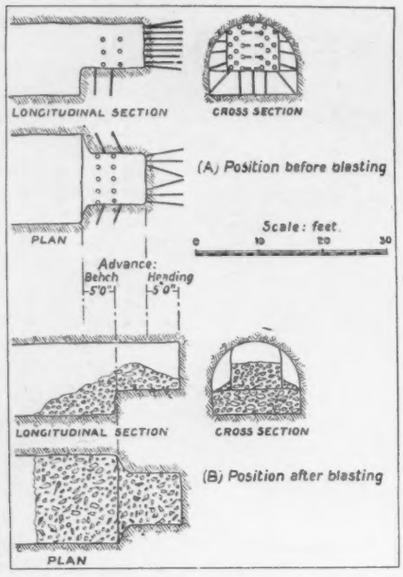
There was also considerable difference in the length of the drill holes. Long holes were driven when the work was being done by "Leyner" drills; but the nature of the ground made holes more than 7 feet long troublesome. The sides of the heading made it impossible to get sufficient slope for deeper cut holes; and difficulty was always experienced in trying to blast a clean cut. The cut



Completing the reinforced-concrete pillars at the inlet gates.



Receiving station on the outskirts of Bombay.

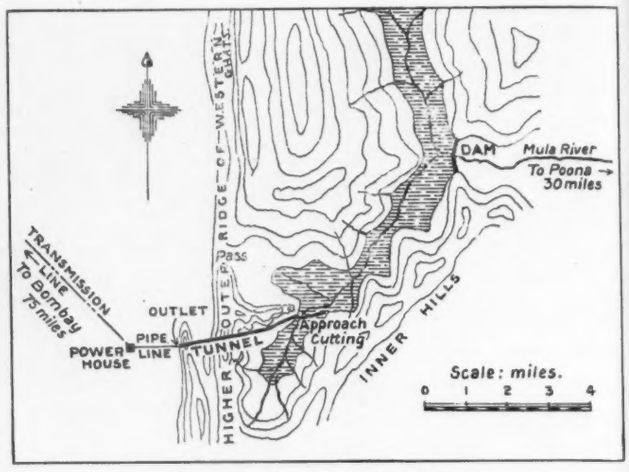


Diagrams of drill rounds and of the disposition of rock after blasting.

was therefore kept down to a maximum of 6 feet—the average being much less.

It was ascertained that the old Sergeant drills, which had been brought from another job and were of the reciprocating type, could not compete with the "Leyner" hammer-type drills with free steels. Therefore, the use of the "Leyner" drill was enforced as far as possible. It must be understood that the labor available was of very poor quality. It included members of almost every race in India, from the Pathans of the northwest to the Madrasis of the south. Except for a few men from the Kolar goldfields, all were unfamiliar with underground work. Local coolies declined to go underground at all, and could be used only for surface work. Even then they were available only when not at work in their own fields. Labor was never the same for two days running, as the pace set was much too fast to suit most of the workers. Hence the least energetic among them were constantly leaving and being replaced by others.

Fatal accidents numbered nine in a total of over a 1,000,000-men shifts; and almost all of them were due to gross carelessness either on the part of the victim or his fellow workers. Two men were electrocuted; four were killed by blasting; two were crushed by falling rock; and one was struck by a falling bucket in shaft sinking. Minor accidents were occurring continually, and were caused by such things as trying to explode a detonator with a lighted cigarette, and the like. The destruction of rats and mosquitoes was carried on relentlessly, and ordinary sanitation was maintained—in short, to keep going, it was a steady up-hill fight all the way through against the ignorance, prejudice, and dirty habits of the workers. That so large and difficult an undertaking was carried out at all in such circumstances reflects great credit upon those responsible for the execution of the project. It took just 20 months to drive the tunnel after the shafts and the adits were completed.

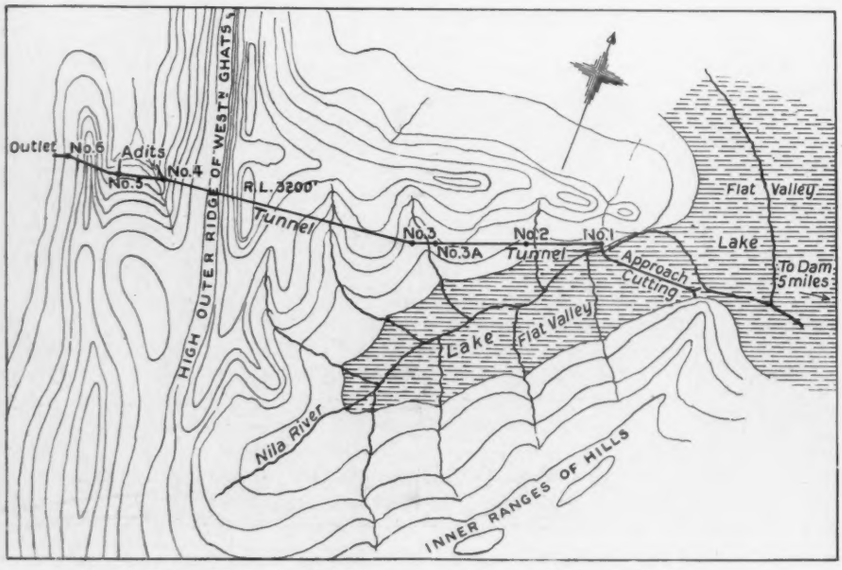


General scheme of the project.

Footage made with the "Leyner" drills was gradually brought up to 100 feet per month at one face; but when the men were allowed to use "Jackhamers," instead, a great increase in footage resulted—the best performance at any one face in one month ultimately reaching 403 feet of full section. Just what the engineers were up against can be appreciated when it is understood that in the present instance, and in all cases, three men were called upon to hold and to work a "Jackhamer" which is a 1-man machine and ordinarily used by one man the world over.

With the "Jackhamers" the workers could return to the face almost directly after blasting and start the upper holes in a heading, whereas it was necessary to clear away a considerable amount of material to get a solid foundation for the "Leyner" columns. In fact, with the inferior labor on the job, a complete cut could be drilled with "Jackhamers" in the time taken to erect a pair of "Leyner" drills. Once rigged, of course, the "Leyner" drill can work more quickly than the "Jackhamer" and make bigger holes with less exertion on the part of the operator. Some of the "Jackhamers" were of the wet type; but, as the contractor found that even the trifling act of manipulating the feed-water tube was too much for the workers, he preferred to drill the holes dry. Where very hard rock was encountered, it was in some cases necessary to put back the "Leyner" drills with their greater power and heavier steels. With the "Jackhamers" were used hollow, hexagon, ⅞-inch steels with double chisel-type bits and with the air-vent hole at the side just above the bit. The contractor used a larger number of holes than is normally considered sufficient, but he did so to insure a clean cut. The amount of explosive required per foot of full-sized tunnel ranged from 8½ to 13 pounds—gelignite being commonly employed.

The inlet to the tunnel is an open approach cutting, 3,000 feet long and 25 feet wide, sloping down toward the tunnel at a gradient of 0.15 per cent. The west end of this approach leads into a short curved tunnel, under the lake near Shaft No. 1, which terminates in a gate chamber 46 feet wide. From the west face of this chamber three small tunnels, 8½ feet wide by 10 feet high, lead downward and join the main tunnel. The mouth of each of these small tunnels is provided with a gate, weighing 8½ tons, which is raised and lowered by a 12-H.P. motor through worm-and-pinion gearing.



Plan of the tunnel line and associate adits and shafts.

The Tata Hydro-Electric Project was carried out under the supervision of Mr. R. J. D. Richardson, a well-known mining engineer, to whom the writer is indebted for permission to publish the data contained in this article.

Helium Greatly Lessens Hazards of Underwater Workers

HELIUM, the rare, non-flammable gas so essential in the safe operation of large dirigibles, has also been found highly useful in making underwater explorations, as a result of experimental work conducted by the United States Navy Department, the Public Health Service, and the Bureau of Mines. The employment of the gas in synthetic helium-oxygen atmospheres for the "decompression," the restoration to normal atmospheric conditions of divers or others performing labor under increased atmospheric pressure, will enable divers to remain submerged for longer periods and to extend to greater depths than was formerly the case.

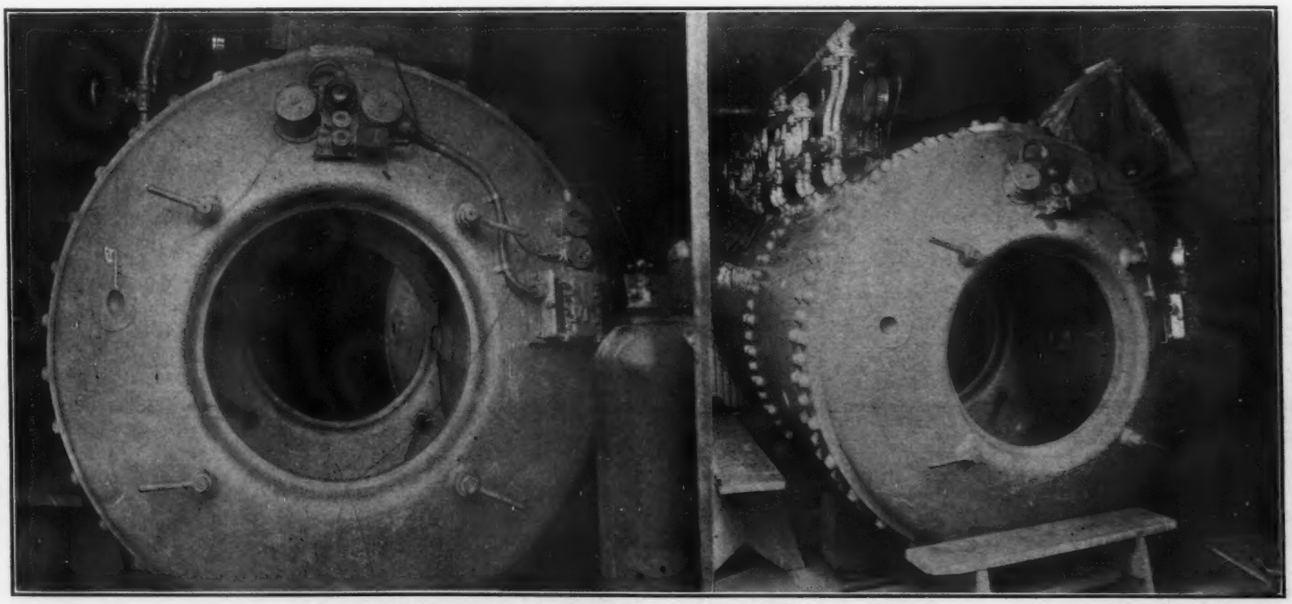
The main obstacle to work of any kind under increased air pressure is the danger of the development of "bends,"—the common term for symptoms of caisson illness. This malady arises from the too rapid decompression of an individual after having been exposed to atmosphere at high barometric pressure. Nitrogen gas exists in the blood and body tissues in simple solution. The amount that will be dissolved depends upon the barometric pressure, the temperature, and the coefficient of solution of the gas, nitrogen. If the decrease in pressure is not carefully controlled, and sufficient time is not permitted for the gas to escape quietly into the blood and thence from the lungs, bubbles will form in the tissues and blood vessels. This bubbling action is very similar to that of a carbonated beverage when the bottle in which it is confined is opened, except that the gas which causes the liquid to effervesce is carbon dioxide whereas in caisson sickness the bubbles are mostly nitrogen. The bubbles are most dangerous if formed in the spinal cord and the brain, causing paralysis or death. If bubbles develop, an additional danger lies in their tendency to increase in size on the further lowering of pressure. There is also the possibility that a number of small bubbles may aggregate to form large ones. Control of decompression to prevent the formation of bubbles is the most difficult problem of caisson and diving work.

Much has been done by the Navy Department and by other investigators in arranging suitable tables for the safe decompression of caisson workers and divers from various pressures and depths of water. Despite precautions in decompression, caisson disease often does develop in an individual following exposure to high pressure. As a rule it can be relieved and controlled by recompression—that is, by putting the victim back under pressure so as to decrease the size of the nitrogen bubbles which are causing the trouble and to cause the symptoms to disappear as soon as adequate pressure is reached. When a subject with bends is recompressed immediately, the symptoms usually disappear. But if recompression is delayed, sufficient damage may be done to body tissue to produce more or less lasting symptoms, or the victim may die because of bubbles in the heart or brain.

A diver may descend rapidly with no ill effects from pressure so long as he keeps his ears cleared—that is, as long as the same pressure is applied inside the eardrum as outside, otherwise he is liable to suffer severe pain if not rupture of the membrane. A good diver can descend to 190 feet in from 2 to 3 minutes without difficulty—in fact, as rapidly as those in attendance can feed out his hose, life line, and telephone cable, which are usually bound together to form a single line.

When ready to start back to the surface, the tenders haul in the line and lift the diver from the bottom. Experienced divers can make themselves more buoyant by increasing the pressure in their diving dress. The ascent, however, is not usually a continuous one. Decompression schedules are based on stages of decompression or rests at varying depths—that is, the diver is hauled up a certain distance and then stopped for a period to allow the excess gas to escape from his body fluids and tissues. The number of these stops increases with the depth and the length of time he was exposed to the pressure at the bottom. In some cases a steel platform is lowered over the side of the diving barge. When the diver undergoing decompression reaches the platform on his way up he is hauled the remainder of the way by a winch or derrick, but stops are made at various intervals as before.

When the diver finally is lifted from the water he is undressed rapidly, sometimes given a stimulant if cold, and always observed for the first signs of bends. If these occur, he is immediately placed inside a specially designed steel chamber and recompressed to relieve the symptoms. If no steel chamber—familiarly called by divers the "Iron Doctor"—is available, the diver may be put down into the water again and thus be subjected to pressure to relieve the symptoms. The period of decompression may be a more or less lengthy one, and is usually fatiguing to the diver. There are times



Left—On the right of the recompression tank are helium storage cylinders from which is drawn one of the ingredients in the synthetic atmosphere that can be used to lessen the hazards of deep-sea diving.
Right—Another view of the recompression tank that has been used by the Bureau of Mines in developing satisfactory helium-oxygen mixtures for deep-sea diving.

when decompression has its risks, for instance, when the man hangs from a vessel that may be suddenly storm tossed.

Nearly all investigators admit that the nitrogen of the air breathed by the diver is the main cause for the bubbles. Normal atmospheric air contains approximately 79 per cent. nitrogen and 21 per cent. oxygen. Rather recently, the Bureau of Mines became interested in pressure and caisson work and, as a result, started investigations at its Pittsburgh Experiment Station. This work was initiated by Dr. R. R. Sayers, chief surgeon of the Bureau; W. P. Yant, associate chemist; and Joel Hildebrand, professor of chemistry, University of California. An attempt was made to develop a synthetic atmosphere which would be more suitable for divers than ordinary air. After a large number of experiments had been made on animals, it was found that by replacing the nitrogen of the air with helium, and also by reducing the oxygen content below that of normal air, an atmosphere could be produced that would permit decompression in one-third to one-fourth the time required for air. Incidentally, the deleterious effects from oxygen poisoning could be prevented.

Helium is about half as soluble as nitrogen, and thereby greatly reduces the amount of excess gas that a man will accumulate in his system while under pressure and that will have to be freed from the blood during decompression. Because the helium molecule is smaller than that of nitrogen it will diffuse more rapidly. This hastens the escape of the excess gas. The quantity of oxygen is controlled within the limits that will not cause deleterious effects and yet be sufficient to perform satisfactory work.

After laboratory tests on animals, the investigators consulted with the Navy Department, and a trial test on men was arranged under the supervision of Chief Gunner C. L. Tibbals, commander of the U. S. Salvage Ship *Falcon*. Chief Gunner Tibbals was the first man to use the synthetic atmosphere under pressure. After a successful experiment, two more of the crew volunteered for tests, which were also successful. As a result, a cooperative investigation was planned between the Navy Department and the Bureau of Mines for the purpose of more thoroughly investigating the advantages to be gained by the use of synthetic atmospheres; to work out favorable rates of decompression; and to make a study of caisson illness with a view to devising ways and means of prevention. Chief Gunner Tibbals and seven experienced divers were detailed to the Pittsburgh Experiment Station to work in conjunction with Doctor Sayers, Mr. Yant, and Dr. Charles K. Reinke, acting assistant surgeon of the Public Health Service, who was also assigned to the medical phase of the work.

During the course of the investigation the work was temporarily discontinued twice to allow the personnel to take part in outstanding diving and salvaging operations; and one of these was the refloating of the U. S. Submarine *S-51*. In the recovery of the *S-51*, the helium atmosphere played an important role: a full tank of a synthetic atmosphere of helium and oxygen was at all times attached to a breathing apparatus in the decompression chamber. In case a diver developed bends, or in case recompression after the development of bends did not correct the condition with satisfactory promptness, the subject donned the breathing apparatus and inhaled the synthetic helium atmosphere while under pressure. His nitrogen was then replaced by the helium; and this gas, being so much more easily eliminated, accelerated his recovery and often removed the symptoms in surprisingly short periods.

The bell of the U. S. Submarine "S-51." Helium helped in the recovery of the stricken craft that carried this bell when she sank after her collision with the "City of Rome" in 1925. At the left, W. P. Yant, Associate Chemist of the Bureau of Mines. At the right, Francis George Smith, Chief Torpedoman, U. S. Navy, the diver who salvaged the bell that is now mounted in the Bureau of Mines Experiment Station, Pittsburgh, Pa.

Were it not for the high cost of helium, the possibilities of a synthetic atmosphere of helium and oxygen, if used during the entire period divers are under pressure, would be almost unlimited. Instead of an hour on the bottom at a 135-foot depth, nearly two hours could be spent there without any increase in the period of decompression. This would permit of much faster operations without the continual interruptions incident to the changing of shifts. Or, on the other hand, work might be carried on by a diver for an hour at a depth of more than 200 feet. This would make feasible the salvaging of many wrecks that have hitherto not been considered recoverable because of the protracted period necessary to decompress underwater workers.

Landsmen may not be generally aware of the intense rivalry customarily indulged in by deep-sea divers for possession of the signal bell of a sunken craft. In the case of the bell of the *S-51*, a most unusual game of submarine hide-and-seek was played by the divers engaged on the job. "It became a matter of personal pride with some of us to keep the bell out of the way of the remainder of the men," says Chief Torpedoman Smith. "Today the bell would be in a given spot; tomorrow some enterprising diver, happening upon its hiding place, might have stowed it away in an entirely new place from which it might have been salvaged by a third party. As the original 'thief' of the bell, I was often hard pressed to keep one guess ahead of the others in discovering new hiding places. The day came when I deemed it wisest to attempt to bring the much-sought-after bell to the surface. I had hidden it for two or three days prior to this in the engine-room, a place frequented by few; but those few were my most formidable competitors. The trail was becoming decidedly hot: I knew that soon someone would be sure to stumble upon the treasure and ruin my chances of being the lucky man. Considering everything, I thought it advisable to bring the loot up before it should be 're-stolen' from me.

"In deep-sea diving, two divers usually work together at each given place of operation. It so happened that one morning I was working with Eadie, a veteran under-sea man. We were engaged upon a risky and ticklish bit of work in the engine-room. Having completed the job in good time we were about to give the signal to those above that we were ready to ascend, when I thought that it was probably the most propitious moment for salvaging the treasure. Accordingly, I brought out the bell from its hiding place and passed it up through the engine-room hatch to the mystified Eadie, who had not in the least grasped the significance of my antics.

"With the bell once safely on the deck of the submarine, I explained the situation to Eadie by means of signs, and he willingly fastened the heavy bell to my diving belt. The fact that this procedure added considerably to my already cumbersome costume troubled me not at all. This done, both of us signaled to be taken up with our long-desired loot, the ship's bell of the lost *S-51*."

Note—We are indebted to the United States Bureau of Mines for the information contained in this article.

The Mount Revelstoke automobile road, in British Columbia, has been completed after being under construction intermittently for the past fifteen years. The distance from the Revelstoke city hall to the summit of the mountain is 19 miles, and the road rises to an elevation of 6,150 feet. It is well graveled, of ample width, and the grades are easy.

Compressed Air Lightens the Work of Installing Heavy Draft Gears

By THE STAFF

IN years past, according to Mr. L. M. Heuchert, car foreman in the Harahan shop of the Illinois Central Railroad, the study of friction draft gears for freight cars was given little attention. For that reason, the work done in this direction and the improvements made by the Illinois Central Railroad in installing these gears are worthy of mention.

With the present heavy steel underframe cars and the increased loading capacity demanded, the desire has been to provide a type of friction draft gear capable of absorbing the shocks due to long trains and to the severe switching stresses to which cars are subjected today. The heavy gear developed for this purpose has proved its efficiency in service by withstanding these shocks and thus preventing the metal parts of a car from fracturing or breaking, and also by absorbing the shocks and saving the superstructure from the harmful effects of continuous jarring. Mr. Heuchert has recently pointed out that the lighter type of draft gears generally resulted in broken metal parts and in the superstructure becoming loose and shaky, tending to that extent to impair if not to shorten the life of the car.

However, when it came to installing these heavy draft gears under freight cars the shopmen encountered considerable difficulty. Like other railroads, the Illinois Central found that the great weight of the gears made it hard to get them in their designed places beneath the cars. Then, too, there was the problem of compressing the gears so that they would function properly. To quote Mr. Heuchert: "Considerable work in renewals of draft gears has been performed in our shop. Formerly, we assembled draft gears by hand, using a clamp to draw up the compression. This entailed considerable expense for labor. To this had to be added the cost of placing the gear in the yoke, rolling it under the car, and jacking it between the metal draft arms in its right position. In order to install it, some railroads found it necessary to jack the car off the trucks and then to jack the gear up between the draft arms.

"Finally, it was decided that we would have to build some kind of a machine that would enable us to assemble friction draft gears at our Harahan shop at a lower cost; and Mr. Stengel, our roundhouse foreman, was requested to assist the car department in determining if suitable machinery could be made to take care of this work. How well they succeeded can be gathered from the accompanying pictures which show the manner of assembling these gears and of placing them in position under the cars.

"The machine was first put in operation in our shop on August 17, 1925; and since that time we have assembled approximately 350 car sets of gears and applied them at a cost of $2.24 per car. By the old method, the same work cost $3.58 per car—making a net saving of $1.34 per car. The machine was constructed at our local shop, under the direction of foreman Stengel, for about $350. It consisted of the following material: one cast-iron face plate mounted on roller-bearing axles; two air cylinders, each 18 inches by 8 inches; a revolving boom provided with an air lift; the necessary equipment for different type draft gears; and a roller table for rolling the gears in place under the cars.

"After the gear is assembled in its entirety it is lifted up from the revolving table by the boom; the boom is swung; and the gear in the yoke is placed on the roller table that is set on the axle underneath the car. The gear is then rolled into position between the draft arms. Assembling the gear and placing it under a car requires six man-hours per car. This air-operated device has demonstrated its worth, and has been of great help to us in the Harahan shop."

WORLD'S LARGEST TURBINE NOW BUILDING

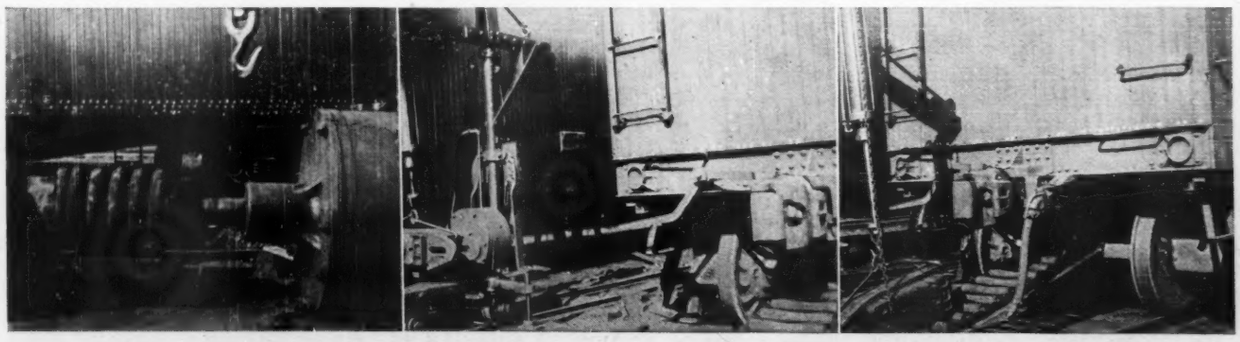
THE world's largest steam turbine generator is now in course of construction in the plant of the General Electric Company. This turbine is the first unit to be installed in the power house of the State Line Generating Company, on the shores of Lake Michigan, and is rated at 208,000 kilowatts, or nearly 280,000 H. P. It is about three times as large as any of the generators in service today and again as big as any unit now building elsewhere in the world.

Other outstanding facts about this steam turbine are: it will incorporate the largest 1,800-revolutions-per-minute generator ever constructed; it will be the first to use live steam for reheating; it will be the first turbine-generator to produce current at 18,000 volts; and it will generate electricity for the interconnected power companies of the Chicago-Illinois-Indiana district. This district was called by the late Dr. C. P. Steinmetz "the greatest pool of power in the world."

BLUE ASBESTOS FROM THE TRANSVAAL

THE existence of blue asbestos in the Transvaal has been known for years; but heretofore mining for the mineral has not been conducted on a commercial scale because of the presence in the rock of specular iron crystals that render the fiber very brittle and make it hard to separate the filaments.

But now we learn from *The South African Mining & Engineering Journal* that it is entirely feasible to satisfactorily separate this asbestos in machinery recently invented for the purpose. As a result, there has been great activity of late in staking out areas for blue asbestos around Potgietersrust and Rustenburg; and there is talk of a large monthly output of "blue" from the Transvaal within a short time.



Various stages in assembling heavy draft gears. The use of compressed air has speeded up and greatly lightened the work.

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—Founded 1896—

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EDITORIALS

LIFE'S LENGTHENING SPAN

WE have it on the authority of Prof. IRVING FISHER of Yale University that "We shall actually become a nation of octogenarians by the end of this century." And Professor FISHER has declared his willingness to bet ten dollars to one that his prophecy will come true.

Just how the average person will look upon this prospect of increased longevity is, of course, a matter for individual reaction; but the outlook is one that does concern all of us either directly or indirectly in many ways. First, if we be really useful members of society, then there is the prospect of added years of usefulness that will contribute just so much more to the commonwealth. Furthermore, with the outlook for longer service, we are incidentally warranted in spending just so much more time in preparing ourselves for our life work.

An eminent surgeon, in a recent address, said: "Considering the average 150-pound body of a man from its chemical aspect. It contains lime enough to whitewash a fair-sized chicken coop; sugar enough to fill a small shaker; iron to make a tenpenny nail, plus water. The total value of these ingredients is 98 cents. Yet the insurance companies place the economic value of a man at $5,000. How do they account for the difference of $4,999.02?" The answer was, "The value of the spirit within the man."

The spirit of the individual is largely what it is made by guidance in infancy; by strengthening during the years of schooling; and rounding to its best through the entire period of mature experience. The prospect of 80 years of physical fitness, together with certainly a correspondingly longer period of mental alertness, augurs well for the future of the nation if those of us of healthy bodies and minds do our best to make the most of our strength and faculties which now have gained so much through modern methods of combating the inroads of disease.

MORE WORK FOR THE ROCK DRILL

THE City of Greater New York, with its rapidly growing population, was face to face with an acute water shortage during last September when a period of drought prevailed in the Catskills, from which the Metropolis obtains the major portion of its water supply.

That situation has speeded up action looking to a prompt solution of the city's water-supply problem, which has grown in gravity from year to year despite the vast sum that has already been spent in an effort to fill the municipality's cup. According to responsible engineers, the present water resources will be inadequate by 1935 when the population of Greater New York will have reached a total of 9,000,000.

As is well known, the Delaware River has been suggested as a possible source of relief; but the Delaware River lies mostly outside the State of New York. It would be necessary, therefore, to obtain the assent of Pennsylvania and, probably, New Jersey to any project which might diminish the flow of water through those states. This approval would certainly be subject to delay, even if accord were finally achieved. Accordingly, the Board of Water Supply has offered a new plan of relief which can be put through quickly without seeking the consent of neighboring commonwealths. In short, it is proposed to tap the watersheds of Duchess, Putnam, and Rensselaer counties.

These watersheds lie north of the Metropolis a matter of substantially 150 miles, but their run-off would suffice to increase the city's water supply by 432,000,000 gallons daily. To develop the region in question for the purpose mentioned would entail an outlay of $347,934,000. To this sum would be added an expenditure of $67,000,000 for the driving of another tunnel through rock to carry water from Hill View Reservoir through the eastern section of the Bronx, under the East River to Queens, and thence to Brooklyn in order to connect with one of the main arteries of the present system of distribution.

Besides driving this tunnel, the rock drill would have much other work to do in excavating rock in rearing dams for the reservoirs, in clearing ways for conduits, and in driving connecting tunnels wherever the line or lines of the system would have to pass beneath intervening mountains or hills. Inevitably, the impounding of water in the areas under consideration would entail the relocating of existing highways; and we all know how much the modern roadbuilder depends upon the rock drill in carrying to completion the tasks that are now his.

FROM CAPE TO CAIRO BY MOTOR

AS part of his dream of empire, CECIL RHODES looked forward to the day when there should be a railway in Africa extending north and south throughout the length of the continent from Cape Town to Cairo—thus unifying Africa by facilitating intercommunication by rail.

While the empire builder's dream has not yet materialized in the manner that he had in mind, still the various sections of the erstwhile Dark Continent have become interlinked and made relatively accessible through the activities of the roadbuilder who has constructed roads or highways over which the motor car can make its way speedily in covering the 4,800 miles lying between Cape Town and Cairo. We are told that the various links of this vehicular route have been joined together latterly so that it is entirely feasible to make the journey from end to end of Africa if one does not become bored and halt before the trip is completed.

Lord WILTON and Major W. HIBBERT recently made the run between Bulawayo and Nairobi, a stretch of 2,500 miles. They did that distance in ten days without mishap or difficulty of any sort; and they drove an American car that carried a load of nearly a ton. This performance is proof of engineering enterprise, and evidence of the joint benefits conferred upon the public by the roadbuilder and the motor-car builder.

RAILWAYS MAKE RECORD IN ELIMINATING WASTE

IN his annual report for 1926, Secretary HERBERT HOOVER stresses again the question of the elimination of waste in our industrial life, and heartens us by detailing the progress that has been made to this end in some departments of our activities.

In his enumeration of what has been accomplished, he lays particular emphasis upon the elimination of waste in railway transportation. The need of this was urgent; and he points out this fact in this wise: "Probably the most outstanding single industrial accomplishment since the war has been the reorganization of our American railways. Our transportation was not only demoralized by Government operation during the war but had suffered from chronic car shortages and insufficient service after the war and for many years before. The annual loss from this periodic strangulation in transportation was estimated in the department's annual report of 1925 to amount to hundreds of millions a year. The insufficiency of transportation interfered with steady industrial operations, created intermittent employment, increased the cost of production and, through periodic strangulation, caused high prices to the consumer. Manufacturers and distributers were compelled to carry excessive inventories as a protective measure, thus not only increasing the amount of capital required in the

business, but multiplying the danger of loss by price fluctuation.

"The railways, during the past five years, not only have built up adequate service and given a complete correction to these ills, but they have, by great ability of their managers, greatly reduced transportation costs and thus made great reductions possible which would not have been otherwise the case."

LONG-DELAYED VINDICATION

PERHAPS Sir FRANCIS DRAKE will now recompose his bones and rest better in his grave than during the past 338 years, and all because his name has been cleared of one persistent stigma.

Whatever glamor has surrounded the memory of Sir FRANCIS DRAKE, there is no denying that that gallant man of the sea was to a large extent a glorified pirate; and loot and booty—call it what you will—was in his case, as with others of his period and profession, a strong incentive to action. According to his detractors, DRAKE was lured on one memorable occasion from pursuit of his plain duty by this unworthy motive. We refer to his action in 1588, when pursuing the retreating Spanish Armada.

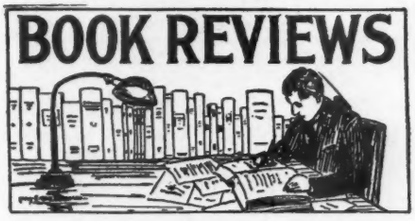
For nearly 340 years it has generally been believed that DRAKE turned his ship aside—after following the retreating Spaniards for a time during the darkness of night—to gratify his personal hankering for loot. That is to say, he dropped out of the line and captured a rich Spaniard that had fallen behind the rest of the fleeing survivors of the Armada—incidentally leaving his chief, Lord HOWARD, in an unsupported position which might have made him comparatively easy prey for the Spaniards had they turned about and attacked him.

Although DRAKE served his country conspicuously, if not notoriously, for years after the defeat of the Armada, still there lurked in the popular mind—and historians repeated it—that DRAKE'S performance at the time mentioned was censurable, despite his official report to the contrary.

Curiously, after centuries, there have been unearthed in Vienna contemporaneous records—among them a letter from a German sea captain—that substantiate the report made by Sir FRANCIS and, to that extent, vindicate him. This clearing of his name is hundreds of years too late to comfort that defamed seaman, but there are probably scores of persons that trace their ancestry back to that doughty gentleman, and to them this revelation of professional probity should prove welcome. Possibly research may some day remove in similar fashion clouds that cast their shadows over other equally outstanding historical characters.

Following the establishment by John D. Rockefeller of an endowment for scientific research in the geology, physics, and chemistry of petroleum, a series of studies in the origin, distribution, and properties of petroleum is shortly to be inaugurated under the joint auspices of the American Petroleum Institute and the National Research Council.

A $500,000 fund has already been provided to finance the work for five years. The results will be of the utmost significance as regards the present status and the future development of the industries based on petroleum, which is still one of the most mysterious of natural resources.



THE STORY OF ELECTRICITY, by W. F. F. Shearcroft. A book of 73 pages, published by Greenberg, New York City. Price, $1.25.

THIS book is one of a series having to do with stories of science, and is written in a popular way in order to appeal to the average reader. The limited size of the volume in relation to the immense field of the subject is sufficient evidence of the extremely general way in which the subject is handled. Even so, we believe the book will prove helpful to many people desirous of having a better grasp of a form of energy that has brought about wonders in modern life.

CORPORATION SECRETARY'S GUIDE, by William H. Crow. A work of 764 pages, published by Prentice-Hall, Inc., New York City. Price, $10.00.

THIS book is intended primarily to fill the need for a comprehensive practice manual and reference book for corporation secretaries. The author's aim has been twofold: first, to be of greatest practical value by offering subject matter that relates especially to secretarial practice; and, second, to offer a fund of serviceable reference material that may meet many emergencies. It is conceivable that the book might prove extremely useful to many that occupy or aspire to fill secretarial positions in corporations.

WHAT PRICE PROGRESS? By Hugh Farrell. A work of 323 pages, published by G. P. Putnam's Sons, New York City. Distributed by The Chemical Foundation, Inc., New York City. Price, $1.00.

IN this volume the author has sought to paint a faithful picture of the position of American industry in relation to the progress of science. Incidentally, while no attempt at a complete survey has been made, the matter presented gives a fairly comprehensive view of the present state of the industrial arts in America. Mr. Farrell has written in a clear, forceful, and entertaining way; and the book should be read by everyone seeking to keep abreast of the times in the matters discussed.

OUR MOBILE EARTH, by Reginald A. Daly, head of Department of Geology, Harvard University. An illustrated volume of 342 pages, published by Charles Scribner's Sons, New York City. Price, $5.00.

MOST of us are firmly convinced that the globe on which we live is decidedly set in its ways, but the author shows us that the terrestrial crust is in a restless mood; and the resultant changes are manifested in numerous ways and in more or less pronounced degrees to those that will use their eyes or modern facilities designed to register these alterations.

Professor Daly has written understandingly and in a fascinating manner about the crust of the earth, its origin, and its structure. It is probably true to say that in all the romance of science there has been no more enthralling chapter penned than that covered by this fully illustrated book.

ADVERTISING COPY, by Lloyd D. Herrold, Associate Professor of Advertising, Northwestern University School of Commerce. An illustrated book of 525 pages, published by A. W. Shaw Company, Chicago and New York City. Price, $6.00.

IN view of the fact that many millions of dollars are spent annually in advertising, it should be self-evident that the better qualified the copy writer the more his text is likely to bring returns and to justify the money expended in its preparation and broadcasting. Failure is often due to the fact that copy is not considered as a part of the entire campaign. Therefore, the author has sought to correct this mistake and to offer mileposts by which the copy writer might follow a path to success. The book is unquestionably the outcome of ripe experience; and Professor Herrold has developed his subject logically and in a lucid manner. The work is made more appealing, more convincing, by a liberal use of illustrations. We commend this book to the attention of those interested in any way in the subject of advertising.

THE STORY OF STEEL, by J. Bernard Walker. An illustrated book of 208 pages, published by Harper & Brothers, New York City. Price, $4.00.

MR. Walker, as editor of the Scientific American, spent several weeks among the steel works of the Pittsburgh District gathering material covering this great field of America's industrial life. Afterwards, he added to his fund of knowledge thus obtained, and the present book is the result of all this accumulated information. Mr. Walker has treated his subject in a non-technical but accurate way, and his volume is a thorough exposition of how steel is made and marketed. Surely we all are aware of the widespread manner in which steel contributes to or affects our daily lives. Mr. Walker's work will help to a better understanding of our indebtedness to steel.

Clearing the Way for the Comforts of Life. This is the title of a picturesquely illustrated brochure issued by the Ingersoll-Rand Company, 11 Broadway, New York City. It describes entertainingly the debt America's prosperity owes to the builders and to the operators of the country's railroads. Many of us are unaware of the magnitude of this indebtedness. The pamphlet can be had gratis upon request of the company mentioned.

Commercial & Industrial India. This is a new monthly published in India and intended to exploit the industrial and commercial activities of the country. It will probably be found helpful to anyone doing business or expecting to do business in that country.

Combating Corrosion in Industry is the title of a booklet, of 126 pages, published by *Chemical & Metallurgical Engineering,* New York City. The booklet contains much authoritative information.

Rocks and Minerals. This publication is issued quarterly at Peekskill, N. Y., and is devoted chiefly to rocks, minerals, ores, crystals, and gems, in the interest of the general collecting public.

The Maxim Silencer Company, Hartford, Conn., has recently issued a series of bulletins describing various models and applications of its silencers. These bulletins can be had free upon request.

Coxe Traveling Grate Stoker is the subject of a catalogue recently issued by Combustion Engineering Corporation, New York City. This catalogue will be mailed to any interested person upon request.

Abnormal vs. Normal Tool Steels, by F. G. Sefing, Met. E. This bulletin has recently been issued by the Michigan Engineering Experiment Station of Michigan State College, East Lansing, Mich.

The United States Bureau of Mines has recently issued the following new publications:

Gold, silver, copper, lead, and zinc in Idaho and Washington in 1924, by C. N. Gerry.

Iron ore, pig iron, and steel in 1924, by Ernest F. Burchard and Hubert W. Davis.

Lime in 1924, by G. F. Loughlin and A. T. Coons.

Gold, silver, copper, lead, and zinc in Montana in 1924, by C. N. Gerry.

Natural-gas gasoline in 1924, by G. B. Richardson and E. M. Seeley.

Natural gas in 1924, by G. B. Richardson and H. Backus.

Rare metals: Cobalt, molybdenum, nickel, tantalum, titanium, tungsten, radium, uranium, and vanadium in 1924, by Frank L. Hess.

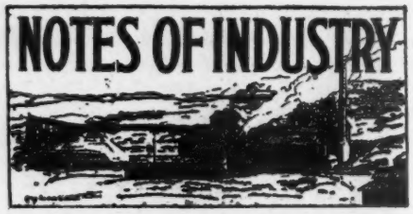
Sand and gravel in 1924, by Estelle R. Phillips.

Orders should be addressed to the Superintendent of Documents, Government Printing Office, Washington, D. C. Price per copy, five cents.

RECOGNIZING PUBLIC SERVICE

SOME weeks ago, the American Institute of the City of New York held its ninety-eighth annual exhibition. The Institute was organized for the purpose of encouraging by recognition any concern that stood forth as a leader in industry or public service. This recognition has been a source of pride to those that have won it.

At the recent exhibition, the Institute awarded honorary fellowships to representatives of 46 firms and organizations that have spent more than 50 years in serving the public; and the recipients had to do with many departments of industry. The Ingersoll-Rand Company, long conspicuous in the field of pneumatic-tool production, was one of the firms chosen for recognition on that occasion.



Extensive phosphate beds have been discovered at Kosseir, Egypt. An Italian company has secured a concession for the working of those deposits.

Last year, the railroads in the United States built 644 miles of new trackage, as compared with 579 miles in 1924. As a matter of fact, more miles of new line were added in 1925 than in any other year since 1919.

Oil has been discovered near Skelleftea, Sweden. The new field, according to government experts, promises to be of greater commercial value than was at first realized.

Expert information on roadbuilding problems is henceforth to be exchanged between the United States and Germany as a result of the visit to Berlin of members of the American delegation to the International Roads Congress held recently in Milan, Italy.

Federal statistics reveal that a total of $260,000,000 is invested in the United States in the crushed-stone industry. This industry produces about 100,000,000 tons annually, and gives employment to 200,000 people.

Mines in Alaska produced $18,220,692 worth of minerals in 1925, as against $17,457,333 worth in 1924.

Tokyo will be the first city of the Far East to have a subway. Work on the project is now well underway.

According to data recently compiled, an average of 142 pounds of fuel was required in the first six months of 1926 to haul 1,000 tons of freight and equipment—including locomotive and tender—a distance of one mile. To do the same work within the same period in 1925 called for an average of 144 pounds of fuel; and in 1923 something like 170 pounds was needed. The increased efficiency is attributed to improved types of locomotives, rigid inspection of coal, instruction of firemen, and an increase in the length of the "run."

Research work, conducted by the United States Bureau of Standards, has proved that the strength of Portland cement drain tile is materially increased by placing the tile in a bath of molten sulphur until it is thoroughly impregnated. While the treatment does not prevent ordinary deterioration, the experts claim that it tends to lessen the capacity of the tile to absorb water.

We learn from *The Oil and Gas Journal* that the 85,000 miles of trunk and gathering pipe lines in the United States represent an investment of $800,000,000 and transport 2,000,000 barrels of crude oil daily.

Two German chemists, Professor Paneth and Doctor Peters, of the Berlin University, claim to have transformed hydrogen gas into helium.

One pound of coal is equivalent to 11.225 cubic feet of natural gas, while one pound of oil is the equivalent of 18 cubic feet of natural gas.

There are more than 20,000 oil wells in the State of Texas. These wells produce in excess of 500,000 barrels of petroleum daily.

Electric light and power companies in the United States now generate more energy than do the public utilities in all other countries in the world combined.

At the present rate of shipment, the consumption of copper in the United States during 1926 will exceed 1,750,000,000 pounds. This is the greatest demand ever recorded in the history of the industry, not excluding the war years.

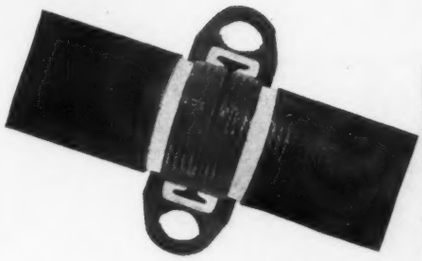
The demand for hydro-electric power in Italy is on the increase, and it is estimated that the 1926 consumption will exceed that of the year preceding by about 18 per cent. There are at present 86 reservoirs in Italy having a total capacity of 1,047,000,000 cubic yards. To this will be added about 2,050,000 cubic yards when reservoirs now under construction are completed.

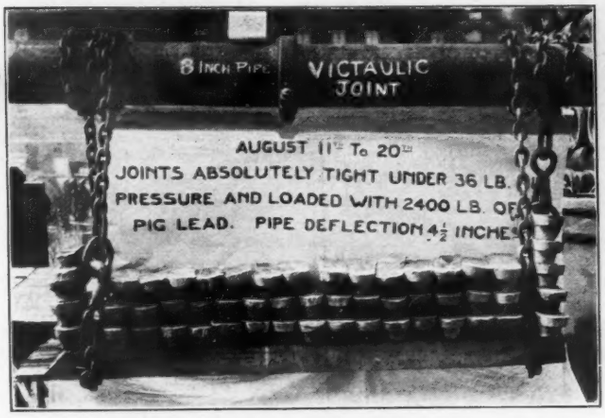
As a result of experiments made by the maintenance forces of one of the State Highway Commissions, it is likely that oil may be used instead of calcium chloride or water to settle the dust on state roads. The fuel oil employed for the purpose is applied cold and under pressure—the quantity varying with the amount of dust. Like water, the oil acts as a binder that is, however, far more enduring in its effect than water. When oil is used, the highways are not swept; and it is applied at the rate of 1/7 to 1/10 gallon per square yard.

In the last 25 years, the American people have increased their investments in means of transportation from $10,500,000,000 to $50,000,000,000, while the annual expenditure for transportation of property and persons has risen from about $1,500,000,000 to nearly $20,000,000,000. Brought down to more understandable terms, the figures reveal that approximately 25 per cent. of the nation's annual income is spent for transportation in one form or another.

Irregular pieces of slate of a class usually discarded are finding increasing use for floors, walks, and rustic pavements, according to the United States Bureau of Mines. Fragments of different sizes and shapes are also employed in making a rough-cleft masonry wainscoting that is attracting considerable attention.

According to a report made public at the opening session of the American Gas Association, held not long ago at Atlantic City, N. J., the manufactured-gas industry is to spend the sum of $500,000 for research work. This money is to be expended over a period of five years in developing new uses of gas in the field of industrial heating and in improving equipment.




8 INCH PIPE
VICTAULIC JOINT
AUGUST 11TH TO 20TH
JOINTS ABSOLUTELY TIGHT UNDER 36 LB.
PRESSURE AND LOADED WITH 2400 LB. OF
PIG LEAD. PIPE DEFLECTION 4½ INCHES

Nine day test of Victaulic Joints by leading public service corporation.

Abused in every way —but this joint stayed tight

TWO full lengths of 8" pipe were coupled with a Victaulic Joint and pressure was applied. Then the center supports were removed, leaving forty feet of pipe suspended, showing a deflection of 4½". Next, a load of twenty-four hundred pounds of pig lead was hung on this Victaulic-Jointed pipe. The Victaulic Joint held.

The yard crane then hooked on to the middle of the pipe and lifted it clear of the supports and dropped it to the ground. Nothing happened to the shock-absorbing Victaulic Joint. At the end of this nine day test, no pressure had been lost.

After abuse such as a joint would never receive in service, the Victaulic Joint was uninjured and leak-tight.

Advantages of this new and improved type of joint

Victaulic Joints can be made by unskilled labor in two minutes.

A Victaulic Joint will not go together properly unless the leak-tight ring is correctly centered and the housings are properly adjusted—perfect joints can be easily made in the dark or under water.

Every Victaulic Joint is an expansion joint.

All Victaulic Joints are flexible and permit up to 5 degrees deflection.

In tensile strength Victaulic Joints equal full threaded, screwed joints.

Victaulic Joints are unmatched for resistance to injury by vibration or ground movement—even an earthquake does not bother a shock-absorbing Victaulic Joint.

Repair and maintenance costs are lower with Victaulic Joints because a defective pipe can be removed and replaced without disturbing any other length.

Victaulic Joints are supplied for steel, wrought iron or cast iron pipes, also for hose—sizes from 1" up—for all pressures low, medium or high.

For detailed information on shock-absorbing, flexible, leaktight Victaulic Joints, for typical installations and list of uses and users, write for Victaulic Bulletin No. 5.

Victaulic Company of America
26 Broadway New York, N. Y.

VICTAULIC

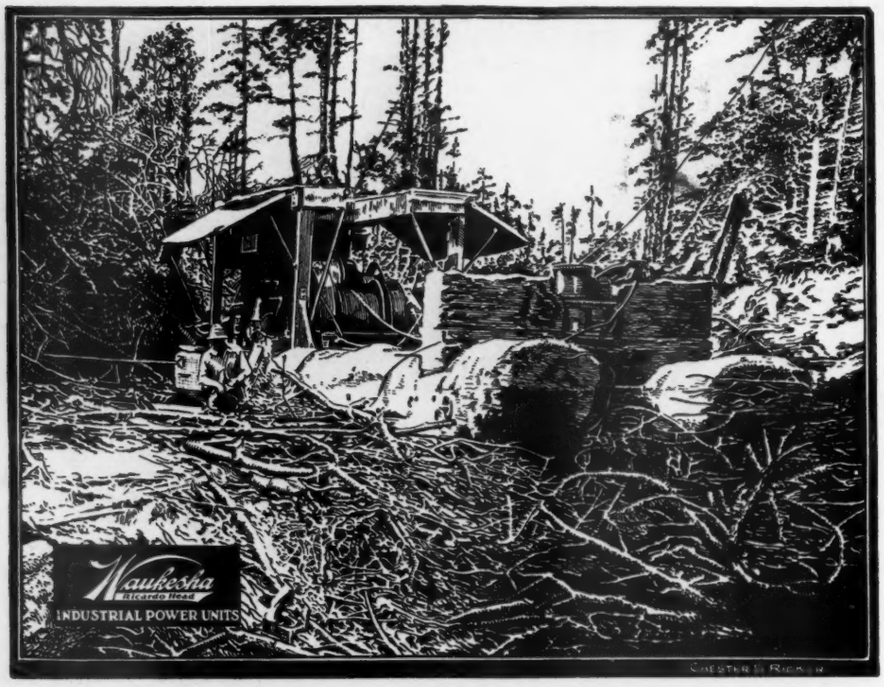
REG. U. S. PAT. OFF.

Flexible and Leaktite Joints

FOR CRUDE OIL, GAS, WATER, SEWAGE, COMPRESSED AIR, ETC.

Please aid the Advertiser by mentioning COMPRESSED AIR MAGAZINE *when writing*

Waukesha Equipped Clyde "Gasoline Donkey" out in Oregon



Down 62% Grades

Pulling themselves up and down over almost impossible grades and at such angles that only a 100 H. P. Waukesha Equipped Clyde "Gasoline Donkey" could operate, is one of the daily tasks of these units. One handled a 2½ yard bucket grading and chunking out continuously for 238 days on double shifts and was only stopped two days at Christmas.

If you have unusually severe conditions to meet, you will find Waukesha "Ricardo Head" Industrial Power Units are particularly adapted to meet them whether it be high power, economy of fuel or operation at severe angles. Write for "Industrial Applications" a very informative book to which you are welcome.

INDUSTRIAL EQUIPMENT DIVISION

WAUKESHA MOTOR COMPANY
Waukesha Wisconsin

New York	Kansas City	Denver	Tulsa	Houston	San Francisco
Aeolian Building	*V. L. Phillips Co.*	*Wilson Machy. Co.*	*C. F. Camp Co.*	*Portable Rotary Rig Co.*	*C. A. Watts*

Exclusive Builders of Heavy Duty Gasoline Engines for Over Twenty Years

As a matter of reciprocal business courtesy help trace results

Progress

Progress in the design and construction of Compressors has been persistently steady.

Frames and general construction are gradually becoming less bulky. Yet the Compressors are stronger and have the more graceful lines of a modern automobile.

Valves are being made on more scientific principles, hence are operating more quietly and, due to less resistance, more efficiently. Excessive noise indicates excessive strains which perceptibly shorten the life of valves. A silent valve is a long-lived one.

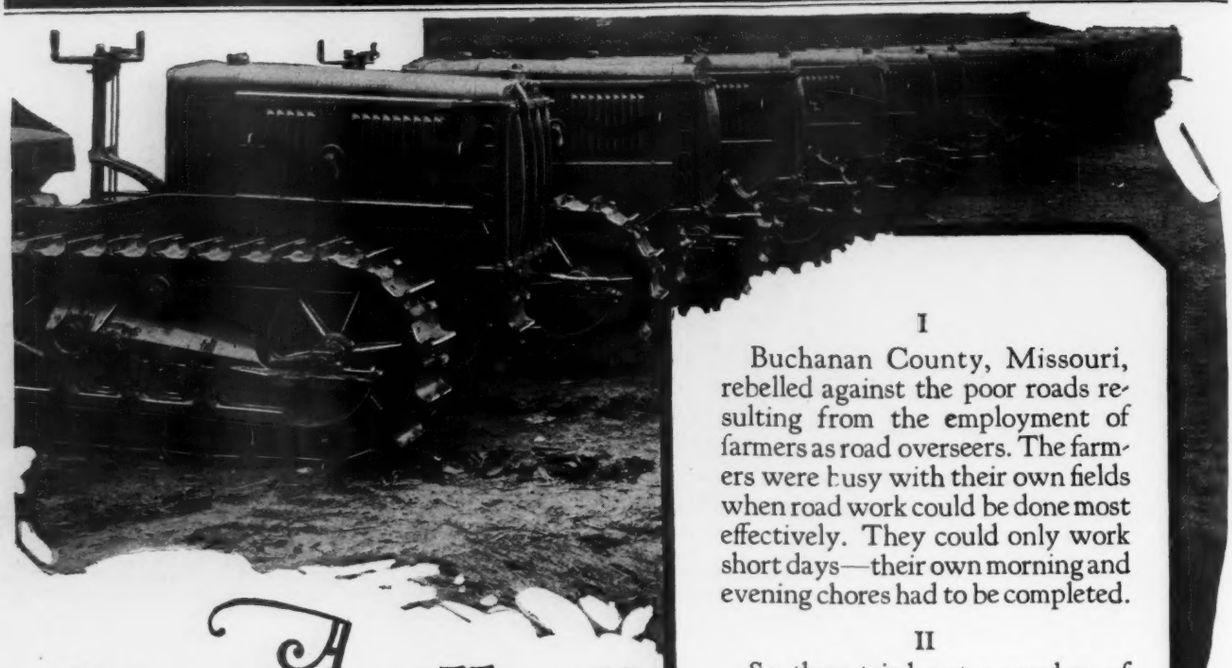
Efficient regulation of the Compressor at full and partial loads has been developed. This keeps the power input in proportion to the air compressed.

Ingersoll-Rand Compressors have been the leaders in these developments. Their duplex construction, Plate Valves, and 5-Step Clearance Control are outstanding achievements.

When you consider another Compressor, whether it is for air, gas, or vacuum, consult the nearest of the Ingersoll-Rand Branches.

Ingersoll-Rand 864-C

Please aid the Advertiser by mentioning COMPRESSED AIR MAGAZINE *when writing*



A "Caterpillar" Tractor Scenario Entitled GOOD ROADS-

BETTER
QUICKER
CHEAPER

There is a "Caterpillar" dealer near you

CATERPILLAR TRACTOR CO.
Executive Offices: San Leandro, California, U. S. A.
Sales Offices and Factories:
Peoria, Illinois San Leandro, California
New York Office: 50 Church Street
Successor to
BEST C. L. Best Tractor Co. The Holt Manufacturing Company HOLT

106-1226

I

Buchanan County, Missouri, rebelled against the poor roads resulting from the employment of farmers as road overseers. The farmers were busy with their own fields when road work could be done most effectively. They could only work short days—their own morning and evening chores had to be completed.

II

So they tried out a number of tractors and finally purchased a 2-Ton "Caterpillar".

III

On the strength of the performance of this tractor, the County then purchased thirteen additional "Caterpillars".

IV

The forty-one farmer overseers were replaced by fourteen full-time patrolmen (each with a tractor) and two road overseers.

V

The actual recorded saving during the first quarter of 1926 was $7,945.38—at the rate of $30,000 a year.

VI

And roads were better!

"Caterpillar" Tractor Prices

2-TON - - - $1850
(*Peoria, Illinois*)

5-TON - - - $3250
(*Peoria, Illinois*)

THIRTY - - - $3000
(*Peoria or San Leandro*)

SIXTY - - - $5000
(*Peoria or San Leandro*)

CATERPILLAR
REG. U.S. PAT. OFF.

As a matter of reciprocal business courtesy help trace results

The rocks in the above picture were all handled on Western Dump Wagons, during the construction of the Cisco & Northwestern R. R. in Texas. The contractor first loaded his wagon with small stuff, then piled rock on top of the load. The large rocks were pried off with a crow bar and the small material dumped in the usual way.

Western Dump Wagons Will Stand the Pounding of Big Rocks

Western

That's Why

WHILE we cannot recommend hauling three tons of rock in a 1½-yard dump wagon, as shown in this photograph, the strength of the Western Wagon was never more strikingly illustrated.

Strong wood, well seasoned, the right design and experienced workmanship combine to produce dependable Western Wagons.

Bob Murry, wagon dumper with long experience in Missouri, when asked why he preferred the Western, said:

"When I say 'Hi' she dumps quick—she moves faster, turns quicker and easier."

This is the experience of most men that have been long in the earth moving business—Westerns move fast and carry double the load when they have to.

There is a new three-up hitch with the drop tongue that protects the stock in rough going, and an improvement that gives greater clearance in turning.

Furnished with either wood or steel bolster.

Write today for full particulars.

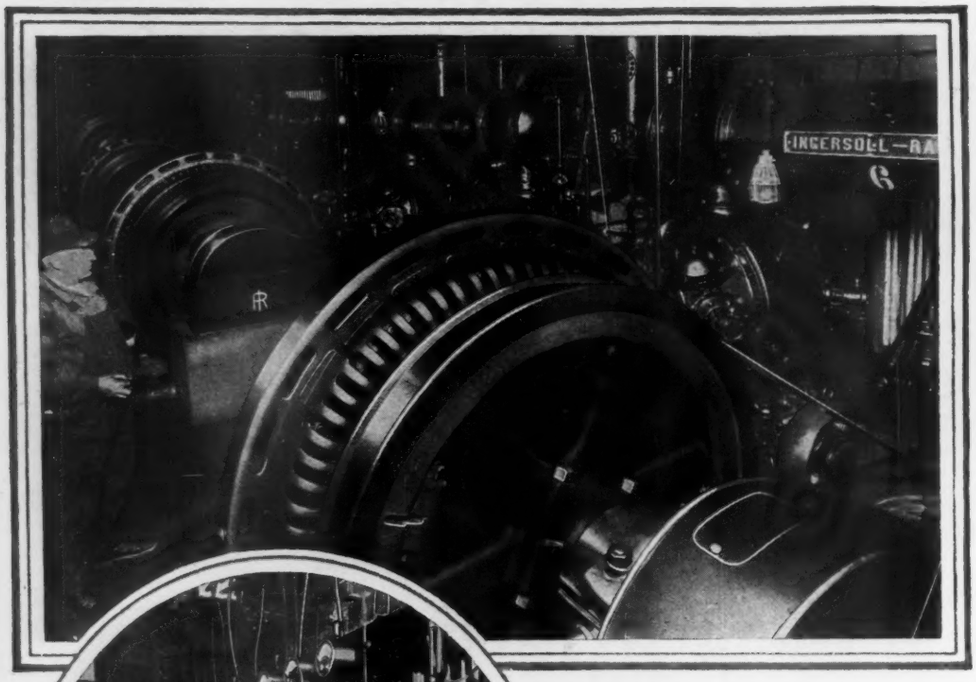
Western Wheeled Scraper Company

FOUNDED 1877

Builders of Dump Cars and Earth and Stone Handling Equipment

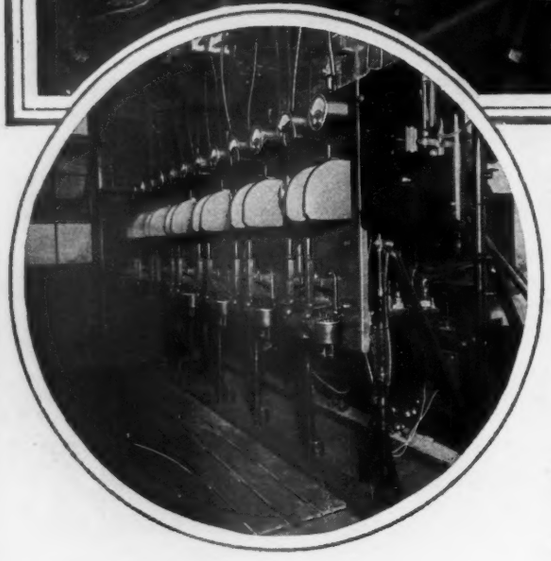
AURORA, ILLINOIS

Digging the Subways of New York



Contract of Rodgers & Hagerty St. Nich.-Bwy. 160-173 Sts.

Six 300 h.p. G-E Synchronous Motors with G-E Reduced Voltage Starters



G-E Synchronous Motors—six of them in line—driving air compressors on the contract of Rodgers & Hagerty. Why G-E Motors?

G-E Synchronous Motors are low in original cost; are high in resale value; have a very good efficiency; are excellent correctors of power factor; are simple in construction and low in maintenance; require very little floor space; are backed up by G-E service—a service known and respected the world over.

These are some of the reasons why the contractors on the New York subways and the contractors on the biggest construction jobs on this continent are using G-E Synchronous Motors for their compressor drives.

Apply the proper G-E Motor and the correct G-E Controller to a specific task, following the recommendations of G-E specialists in electric drive, and you have G-E Motorized Power. "Built-in" or connected to all types of industrial machines, G-E Motorized Power provides lasting assurance that you have purchased the best.

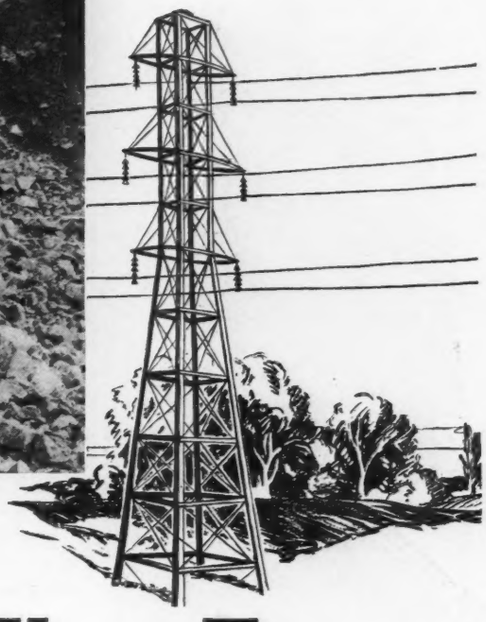
MOTORIZED POWER
-fitted to every need

107-4

GENERAL ELECTRIC

GENERAL ELECTRIC COMPANY, SCHENECTADY, N. Y., SALES OFFICES IN ALL PRINCIPAL CITIES

As a matter of reciprocal business courtesy help trace results



Goodbye Coal and Water Expense

The Bucyrus 120-B Electric Shovel is showing marked savings—lowers tonnage costs

In Mine and Quarry Work

The constantly increasing use of electric power and the resulting cross country high tension lines now make electricity economically available to most mines and quarries.

The 120-B Electric Shovel, drawing power from these lines, is showing a marked swing toward extremely lower tonnage costs in quarrying and open pit mining.

It eliminates the old "stand-by" losses. There is no steam to keep up during waiting periods.

Water and boiler troubles, coal buying and hauling, and the griefs of frozen pipe lines are all done away with.

The 120-B Electric also eliminates the services of a night watchman or fire tender. On the coldest morning, all the operator has to do is throw the switch and this shovel is ready for action.

And with the 4-yard dipper backed by more than enough power to fill it at every pass, the 120-B can increase your yardage per hour—can bring the digging cost per ton still lower.

The Bucyrus 120-B is the only 4-yard electric shovel on the market that combines the digging ability of the railroad type machine with the full revolving swing and the mobility of smaller shovels.

Our new booklet, the *Rock Revolution* illustrates in detail what the coming of electricity means to mines and quarries. Reading it is the first step toward lower costs and higher tonnages.

Send this coupon today for your copy.

Bucyrus Company, (Dept-V)
So. Milwaukee, Wisconsin

Send me a copy of the *Rock Revolution*.

Name ----------

Address ----------

City ---------- State ----------

Company ----------

BUCYRUS COMPANY, SOUTH MILWAUKEE, WISCONSIN

BUCYRUS 758

NEW YORK CHICAGO BIRMINGHAM SAN FRANCISCO PITTSBURGH TOKYO LONDON

OIL
ENGINES
PROVIDE-ECONOMICAL
EFFICIENT - DEPENDABLE-
POWER FOR ALL PURPOSES
POWER problems of many modern industries are being solved by the use of Ingersoll-Rand solid-injection oil engines.
Vertical engines, in sizes from 125 to 1200 h. p., are in service in many power plants, ships, and locomotives.
The largest fleet of Oil-Electric ships in the world under private ownership, and Oil-Electric locomotives in use by eight prominent railroads and several industries, are equipped with Ingersoll-Rand vertical oil engines.
Horizontal oil engines, direct-connected to ammonia and air compressors, or belted to pumps, generators and line-shafting, are proving highly profitable investments for many owners. These units are built in 55-, 110-, and 150-h.p. sizes.
Consult an Ingersoll-Rand engineer when in need of economical, dependable, and efficient power for any purpose. Oil Engine Bulletins will be sent upon request.
SOLID-INJECTION-MULTI-CYLINDER-HORIZONTAL-VERTICAL-4 CYCLE-SINGLE ACTING
INGERSOLL-RAND CO., 11 Broadway, NEW YORK
Offices in principal cities the world over
Canadian Ingersoll-Rand Co., Limited
260 St. James Street, Montreal, Quebec.
Ingersoll-Rand Co. Limited
165 Queen Victoria Street., London E. C. 4
95-SOE
R-1259
Ingersoll-Rand

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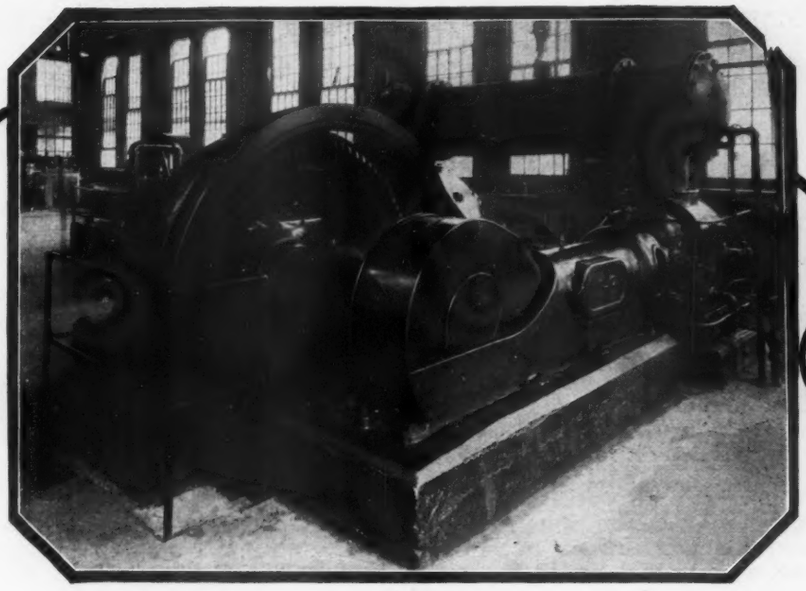


350 hp. 200 rpm. Westinghouse synchronous motor driving compressor installed by King Bridge Co. in 1916.

Reputation

—of men and machines

AN ancient philosopher declared that reputation was "oft got or lost without deserving". He thought in terms of men. Machines are different. None can live long on reputation alone. Competition sees to that. *Good enough* must be constantly discarded for *better*. Reputation must be earned *anew* every day.

The world-wide reputation of Westinghouse synchronous motors as an unsurpassed drive for compressors has been gained by reliable performance day-in and day-out for more than 25 years —its efficiency by untiring research, progressive manufacturing methods and an ever-present willingness to discard *good enough* as fast as *better* can be developed.

The buyer of today's Westinghouse synchronous motor is assured of continuity of service, high power factor, high efficiency at all loads, lower power bills and lower maintenance costs.

Westinghouse Synchronous Motors are used extensively as compressor drive by:

18 Steel Companies

15 Coal Companies

14 Railroads

25 Metal Mining Companies

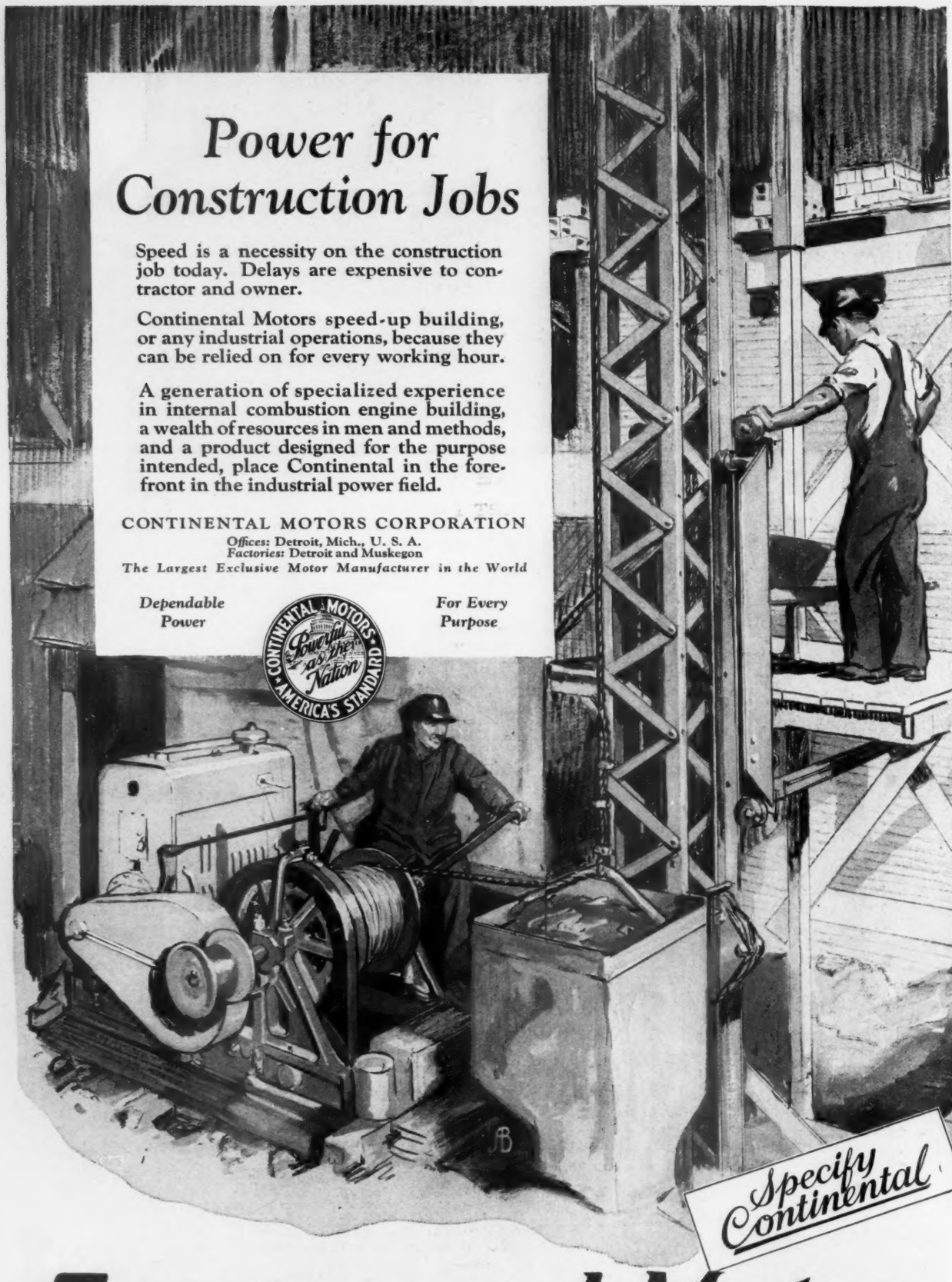
27 Foundries and

29 other miscellaneous industries

Westinghouse Electric & Manufacturing Company
East Pittsburgh Pennsylvania
Sales Offices in All Principal Cities of
the United States and Foreign Countries

Westinghouse

X90084


Power for
Construction Jobs
Speed is a necessity on the construction job today. Delays are expensive to contractor and owner.
Continental Motors speed-up building, or any industrial operations, because they can be relied on for every working hour.
A generation of specialized experience in internal combustion engine building, a wealth of resources in men and methods, and a product designed for the purpose intended, place Continental in the forefront in the industrial power field.
CONTINENTAL MOTORS CORPORATION
Offices: Detroit, Mich., U. S. A.
Factories: Detroit and Muskegon
The Largest Exclusive Motor Manufacturer in the World
Dependable Power
For Every Purpose
CONTINENTAL MOTORS
Powerful as the Nation
AMERICA'S STANDARD
Specify Continental

Continental Motors

As a matter of reciprocal business courtesy help trace results

BETTER MAKE MISTAKES THAN KILL INITIATIVE

No man, nor any organization of men, is right all the time. The only way to avoid all mistakes is to avoid all initiative. Some manufacturers take the attitude that it is their business only to sell goods, and that it is the customers' business to know how to use them. This is a comfortable attitude, and it undoubtedly reduces the manufacturer's chances to make mistakes.

We would rather take the chance of making a mistake in a sincere effort to save money for a customer by recommending a change in the kind of explosive he is using or in his method of blasting, than to follow the easy course of selling him what he has always used, when, in our judgment, this is not the best explosive for his work.

Our salesmen are drilled in this point of view. Admittedly, they are not right all the time; but remember that they are instructed not merely to get the order, but to get the order for the explosives that will break the most material for you, in the best condition, and at the lowest cost. If they insist upon trying to help you, it will be to your interest to consider their recommendations carefully.

For after all, our men are familiar with many blasting operations. They do not know the details of your own work as you do, but they are often able to save money for the man who will interpret their wide experience in terms of his own intimate knowledge of his job.

To mention only a few of the Hercules contributions to better blasting: Hercules Special No. 3 often reduces costs underground in the same proportion that Hercules Special No. 1 reduces costs in the open; Herco blasting saves from 20% to 40% in well-drill shooting when it is applicable; Hercules Extra Gelatins are effecting marked savings by replacing the regular gelatins on many jobs. If not one of these, then perhaps some other suggestion by a Hercules salesman may be valuable to you.

ALLENTOWN, PA.
BIRMINGHAM
BUFFALO
CHATTANOOGA
CHICAGO
DENVER
DULUTH
HAZLETON, PA.
HUNTINGTON, W. VA.
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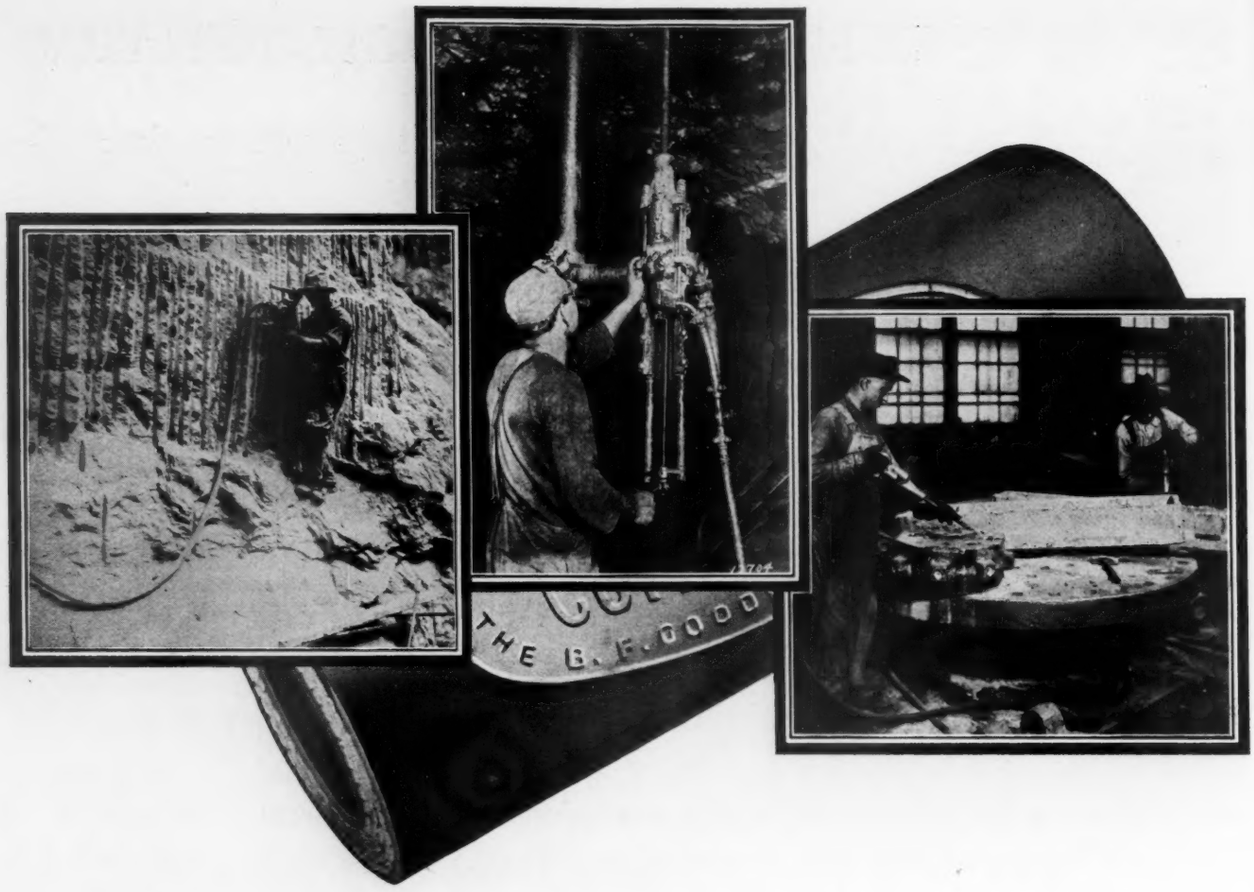
NEW YORK CITY
NORRISTOWN, PA.
PITTSBURG, KANS.
PITTSBURGH, PA.
POTTSVILLE, PA.
ST. LOUIS
SALT LAKE CITY
SAN FRANCISCO
WILKES-BARRE, PA.

HERCULES POWDER COMPANY
(INCORPORATED)
932 King Street Wilmington, Delaware



Forget your "wire-wound" troubles

IF YOU could put a steel jacket on "Commander" it would not wear as long as the Commander rubber cover.

You don't need to worry about bent wire to be straightened out, punctures from broken wire, impeded pressure and all the other drawbacks of wire winding.

The use of "Commander" puts all this into past history.

Its resistance to falling rocks, chafing girders and sharp abrasion is astonishing.

Try to cut that cover with a knife—your blade simply won't take hold.

And the tube is just as good for its purpose—a working partner with the cover that rounds out an unequalled hose value.

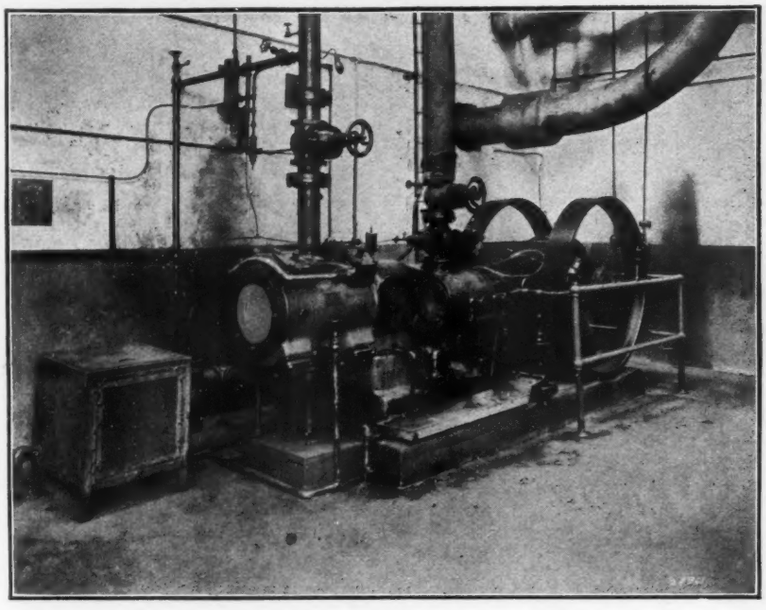
It is nothing unusual for users of "Commander" to write us that they are getting three to four times as long service as they got from other high grade hose.

THE B. F. GOODRICH RUBBER COMPANY
Established 1870 Akron, Ohio

Goodrich
Commander AIR HOSE

As a matter of reciprocal business courtesy help trace results

MIDWEST FILTERED AIR FOR COMPRESSORS



Midwest Type B Air Filter on compressor, in the power plant of Colgate and Co., Jeffersonville, Indiana.

Midwest Air Filters Will Pay Dividends on Any Compressor

THE savings brought about by Midwest Air Filters in the operating and maintenance costs of compressors never fail to exceed by a large margin their low overall operating cost of only 4c a day per 1000 C.F.M. Even if dust conditions in your plant are not apparently severe, you will realize a substantial annual saving if you supply your compressors with clean air through Midwest Air Filters.

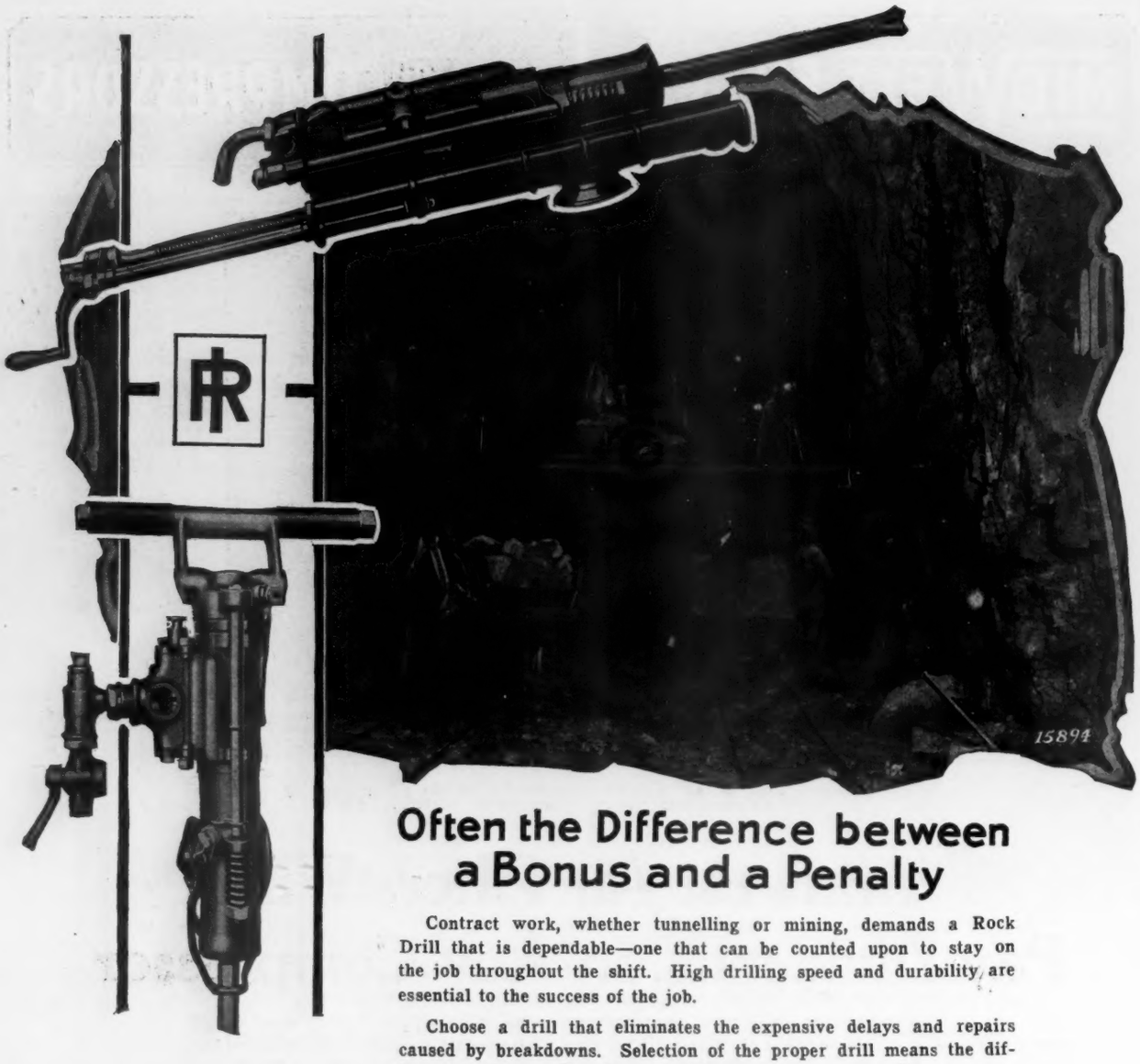
Ask Dept. C for Complete Performance Reports on Midwest Air Compressor and Oil Engine Installations.

These reports not only cover the dust conditions in the plants described, and the savings realized by the use of Midwest Air Filters, but also contain complete data on the operating characteristics and performance of these permament, all-metal, air filter installations.

MIDWEST AIR FILTERS

INCORPORATED

BRADFORD PENNSYLVANIA



"Leyner-Ingersoll" R-72 Drifter and "Jackhamer" Drills driving a large railroad tunnel through a mountain

REQUEST BULLETINS
4062—R-72 DRIFTER
4046—"JACKHAMER"

Often the Difference between a Bonus and a Penalty

Contract work, whether tunnelling or mining, demands a Rock Drill that is dependable—one that can be counted upon to stay on the job throughout the shift. High drilling speed and durability are essential to the success of the job.

Choose a drill that eliminates the expensive delays and repairs caused by breakdowns. Selection of the proper drill means the difference between a Penalty and a Bonus—a loss or a profit.

In driving headings, the "Leyner-Ingersoll" R-72 Drifter has proved its leadership in drilling speed, durability, ease of operation, and economical performance.

The "Jackhamer"—the original down-hole drill—is ideal for removing the bench.

Ingersoll-Rand Drifter, "Jackhamer," and "Stopehamer" Drills are drop-forged from specially selected material. The special heat treatment which they are given assures long, uninterrupted, efficient service.

INGERSOLL-RAND COMPANY-11 BROADWAY, NEW YORK CITY.
Offices in principal cities the world over

CANADIAN INGERSOLL-RAND CO. LIMITED.
260 ST. JAMES STREET. MONTREAL, QUEBEC.

INGERSOLL-RAND CO. LIMITED.
165 QUEEN VICTORIA STREET. LONDON, E.C.4.

16-RDM

Ingersoll-Rand

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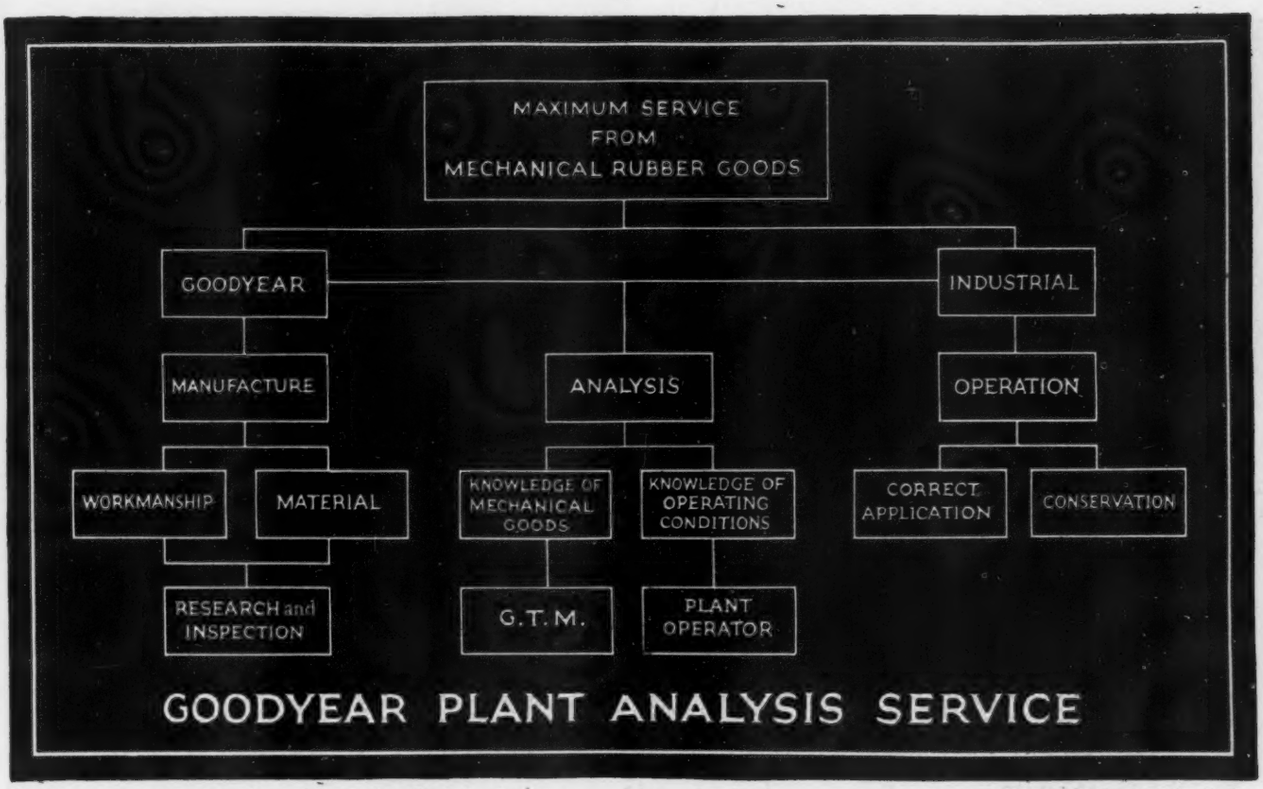


This blueprint charts the orderly relation of the Goodyear Plant Analysis Plan for maximum service from mechanical rubber goods

Copyright 1926, by The Goodyear Tire & Rubber Co., Inc.

The Right Hose for Your Service

Nearly every use to which hose is put in modern industry is a use that demands a particular kind of hose, with qualities all its own.

As you very well know, quite different requirements are exacted from the hose that carries acid, for example, and the hose that carries compressed air. High pressures steadily maintained, and high pressures of pulsating character, call for different body construction in the hose. Washout hose in the paper industry must have a different tube from the tube that is wholly satisfactory for air hose. External punishment, oil in the line, the necessity for extreme flexibility—these are special requirements that must be met by special design.

The utility of a hose, therefore, depends primarily on its maker's knowledge of the working conditions which it is called on to satisfy, and the care with which you use it. The manufacturer of Goodyear Hose is concerned with both these factors, of correct construction for the duty required, and of proper use of the finished product.

The Goodyear Plant Analysis method is the means by which Goodyear helps users of hose to determine exactly what hose construction will serve them most efficiently and economically. As in the case of belting and other mechanical rubber goods, the application of this analysis plan is entrusted to the G. T. M.—Goodyear Technical Man.

The experience of Goodyear in years of careful development of Plant Analysis methods convinces us that proper analysis is exactly as important and valuable in the case of hose as in that of belts. "Just hose" is never so good nor so economical as the "right hose for the job."

The G. T. M. is an expert on hose. He is familiar with the hose requirements of many industries. In co-operation with your plant officials, he will be glad to analyze your hose problems, and help you work out a system of conservation to prolong the life of your hose.

You may depend on Goodyear Hose thus specified to your service, to give you every advantage of efficient and economical operation over a long life. For detailed information about the G. T. M., the Plant Analysis method, and the specialized hose that Goodyear makes for every line of industry, write to Goodyear, Akron, Ohio, or Los Angeles, California.

Goodyear Means Good Wear

GOODYEAR

Ingersoll-Rand Surface Condensers

The experience of pioneering and developing a product—experience which can be gained in no other way—is a tremendous asset to any manufacturer.

Ingersoll-Rand Company pioneered the high-efficiency condenser and is the oldest and most experienced builder of these units.

Ingersoll-Rand Condensers operate on 0.6 to 0.7 sq. feet per kw. There are absolutely no waste or ineffective tubes in the shell.

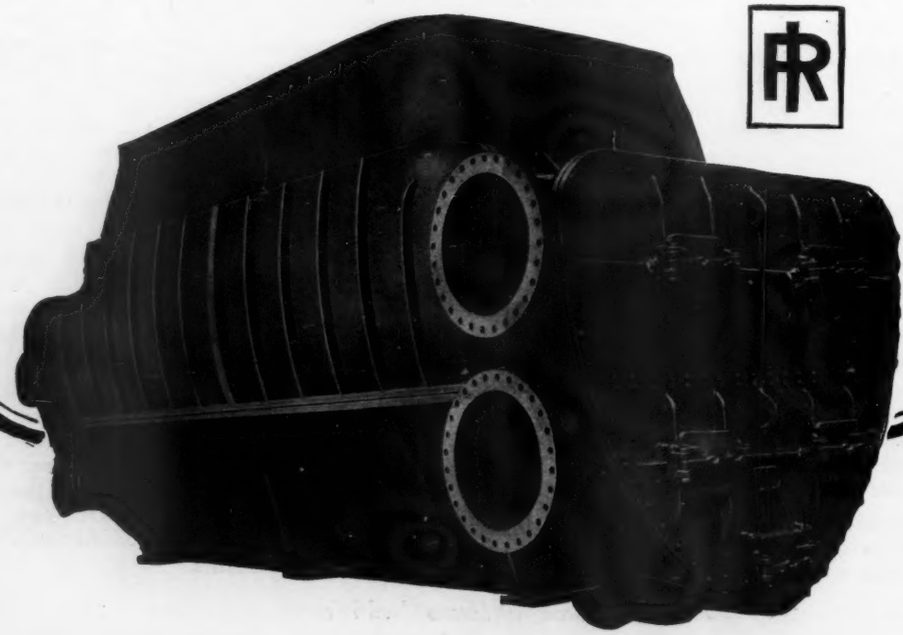
There is no other surface condenser which will operate for so small a cost per pound of steam handled.

Write for Performance Reports.

INGERSOLL-RAND COMPANY • 11 Broadway • New York City

Offices in principal cities the world over

For Canada Refer—Canadian Ingersoll-Rand Co., Limited, 260 St. James Street, Montreal, Quebec



25-SC

Ingersoll-Rand

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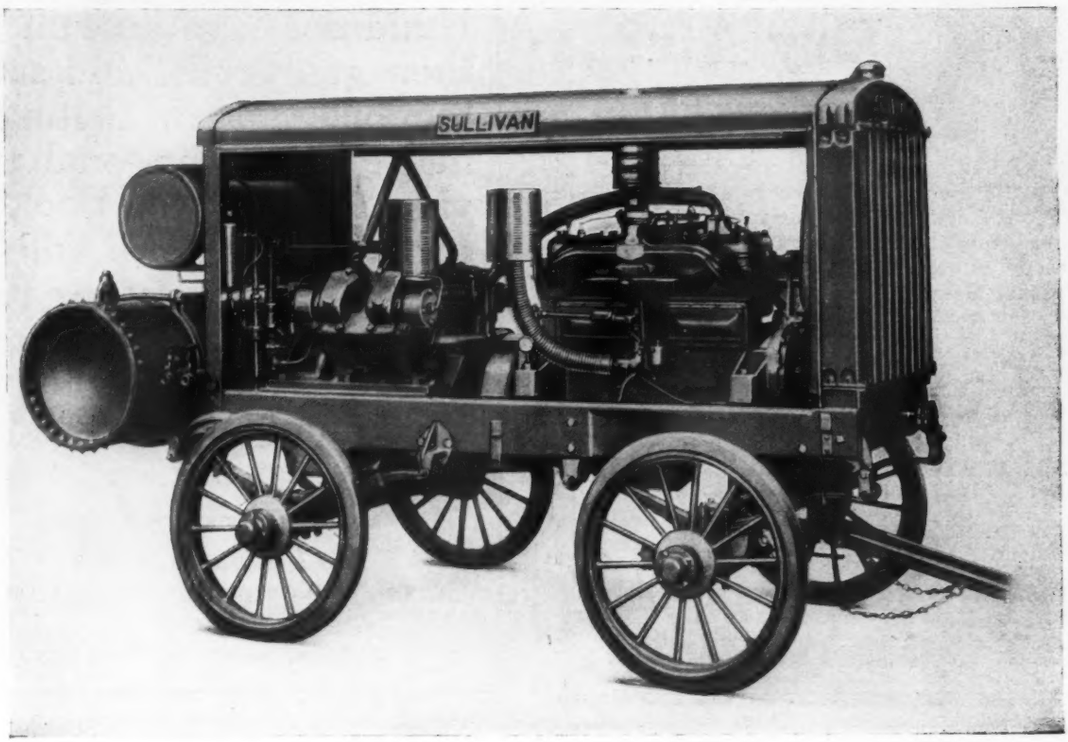
PROTECTOMOTOR FOR PORTABLE COMPRESSORS

REG. U.S. PAT. OFF.
Perfect Positive Protection



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The drawing above illustrates a typical Protectomotor Installation on a standard make of portable compressor. Complete Protectomotor Equipment and Fittings can be supplied for all types of Sullivan, Ingersoll-Rand, Chicago Pneumatic, and other standard makes of portable air compressors. Also all sizes of stationary compressors.

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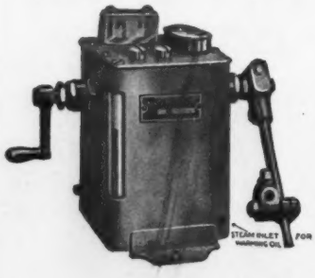

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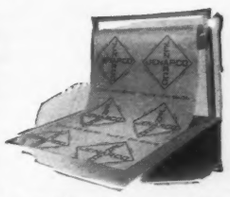

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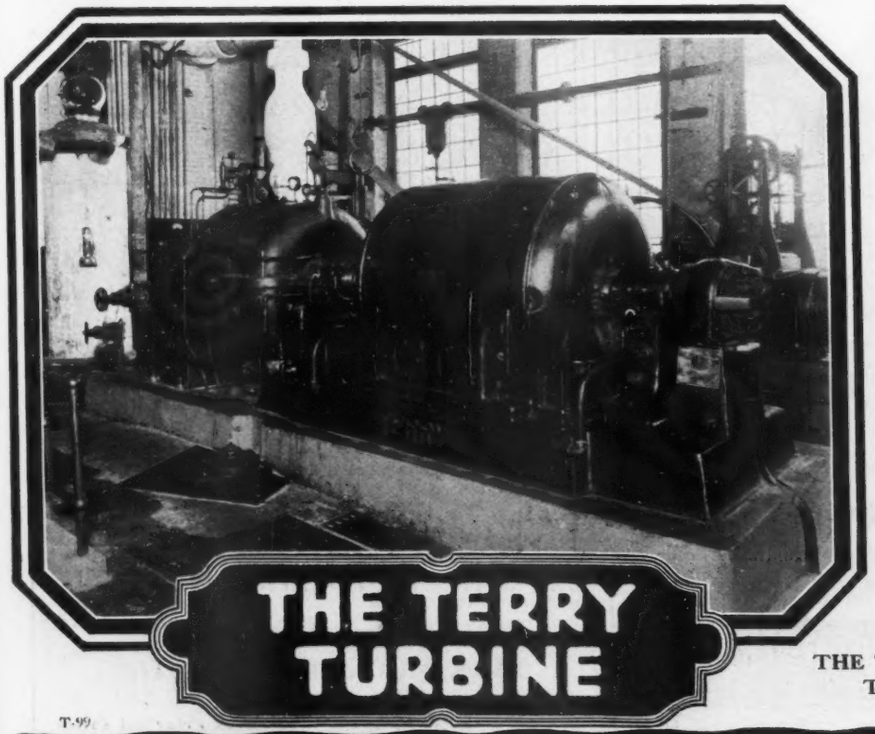

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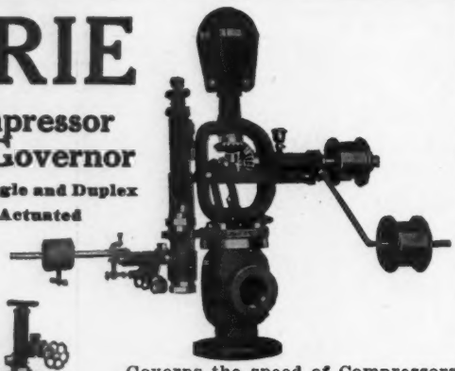

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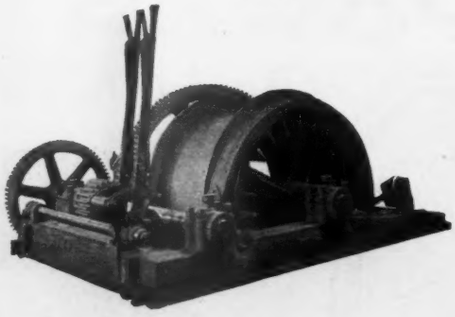

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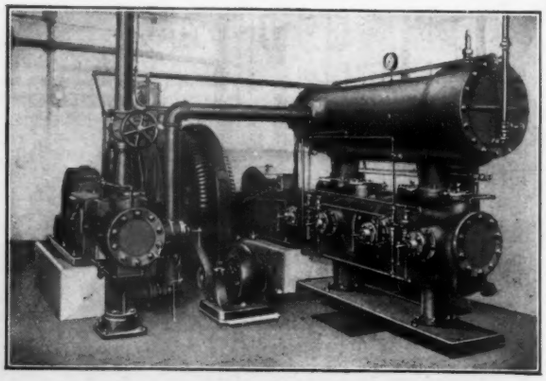

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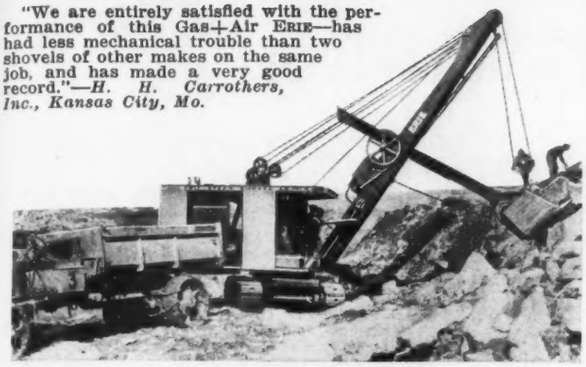

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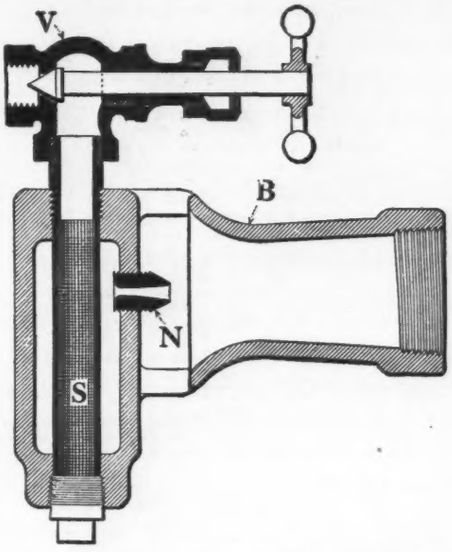

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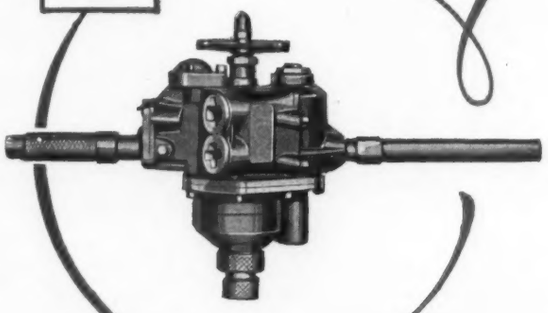

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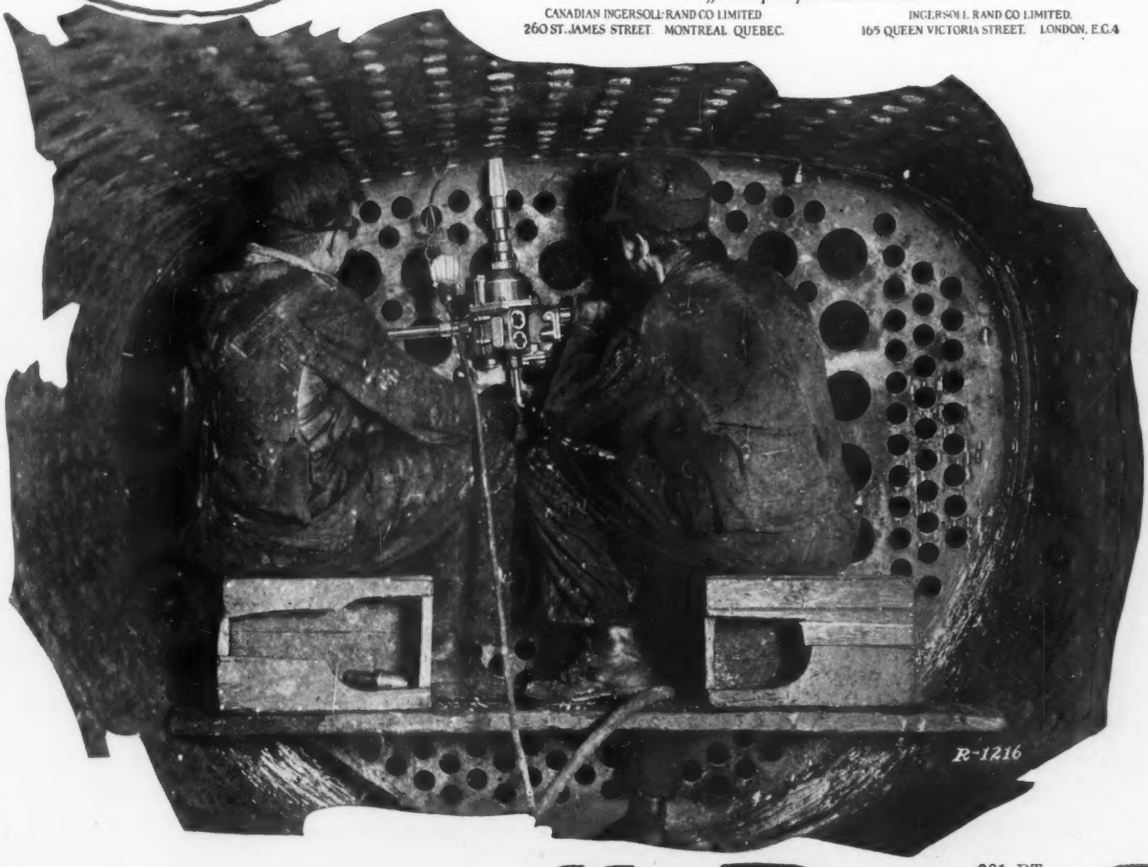

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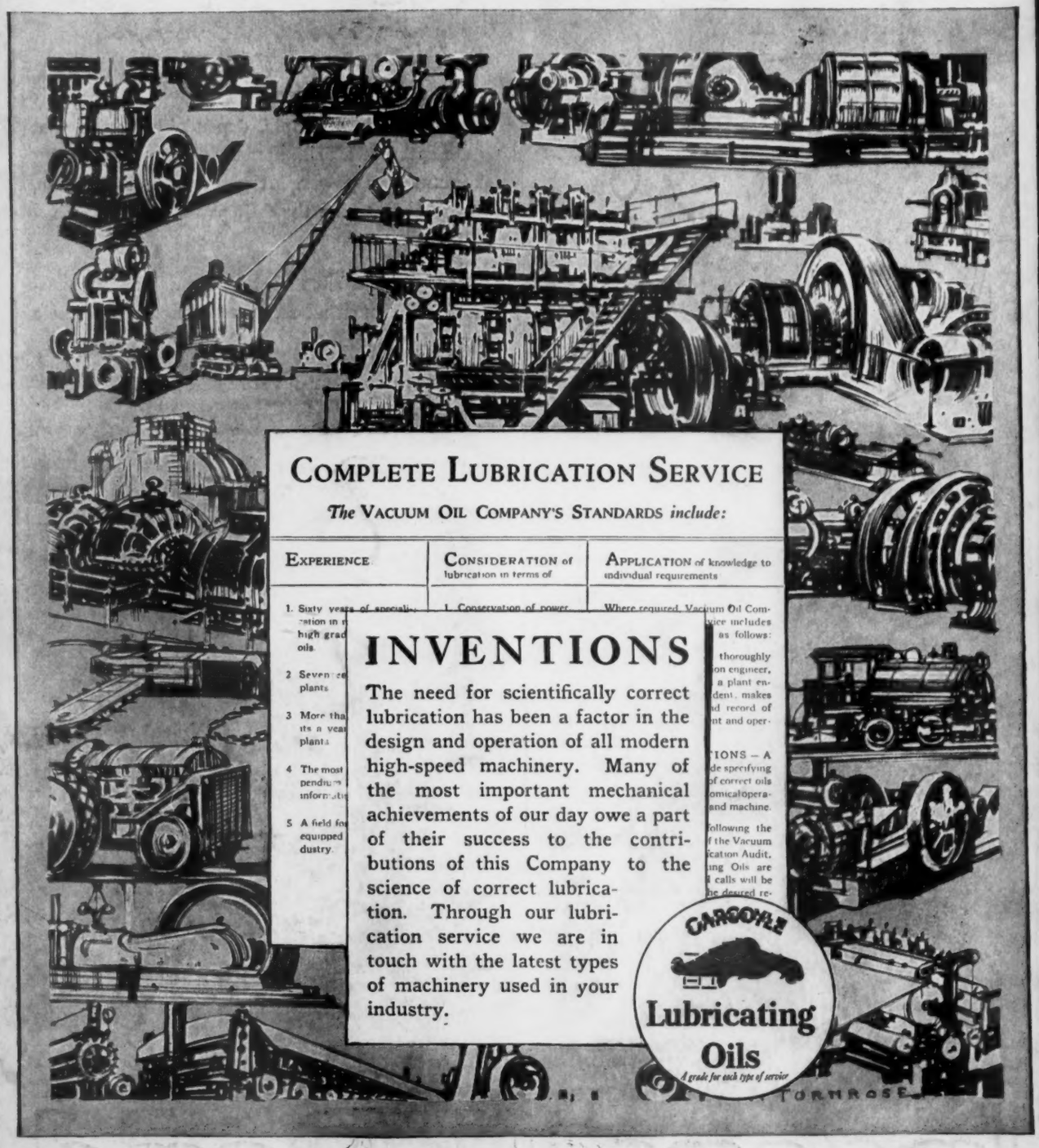
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